SERIES 50 FUNCTION GENERATOR

OPERATION AND MAINTENANCE MANUAL

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F54/F55

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OPERATION AND MAINTENANCE MANUAL

FUNCTION GENERATOR MODELS F54/F55

Serial No. _____

INTERSTATE ELECTRONICS CORPORATION
A Subsidiary Of A-T-O Inc.
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Model F54

Model F55

Figure 1-1. Function Generator Model F54/F55

Section I
GENERAL DESCRIPTION

1-1. INTRODUCTION

This manual has been carefully designed to complement the actual hardware design features of the Function Generator Models F54/F55 (figure 1-1) by providing detailed operation data, extensive maintenance, and performance test information. However, the function generators have been designed so that constant reference to the manual is not necessary in order to operate the equipment. The manual has been designed to provide the operator with an in-depth understanding of the functions, maintenance, and troubleshooting of the units, and to provide specific calibration laboratory tolerances, specifications, measurements, and adjustments in the event a malfunction occurs.

1-2. SPECIFICATIONS

Table 1-1 contains all key performance and physical specifications for the Function Generator Models F54/F55. Confirmation of performance within these specifications may be obtained by conducting the performance test routines presented in Section V of this manual. Outline mounting dimensions are shown in the installation diagram, figure 2-1.

1-3. DESCRIPTION

The Interstate Function Generator Models F54/F55 are state-of-the-art signal sources designed for great versatility, maximum ease of operation, and long operational life.

The case enclosing the function generators provides exceptional physical ruggedness and utility together with effective electrostatic sheilding. The latter is important for the radio-frequency operating ranges of the instruments. Attention has been given to ground isolation applications and a grounding strap is provided at the rear of each instrument. The variable position handle permits the function generators to be tilted at the optimum angle for the operator. The handle facilitates carrying to new locations and serves as a cable strain relief when extended to the rear.

The serial number and other identification data are located on the metal plate at the rear of the instrument. This metal plate also serves as the primary heatsink for the power supply.

1-4. CAPABILITIES

The Function Generator Models F54/F55 selectably provides the following broad selection of output waveforms from the 50 Ω OUTPUT front panel connection:

- Sine
- Square
- Triangle
- Ramp (15/85 duty cycle)

- Inverted ramp (85/15 duty cycle)
- Positive-going pulse (15 percent duty cycle)
- Negative-going pulse (15 percent duty cycle)
- Rectangular pulse with continuously variable duty cycle (100 nano-second minimum pulse width)
- Sweep sawtooth waveform
- Any of the above offset positively with respect to ground
- Any of the above offset negatively with respect to ground

In addition to these nine main output waveforms, there are five auxiliary fixed outputs continuously available at the front panel, each delivering 2 volts p-p in 50 ohms or 4 volts p-p (open). The five are:

- SWEEP SYNC(Sweep pulse output)
- SWEEP MON (Auxiliary sweep waveform)
- SINE MON (Auxiliary sine waveform)
- TRIANGLE MON (Auxiliary triangle waveform)
- SYNC OUT (Rectangular waveform)

There are three input BNC connectors which aid in the versatility of the F54/F55. These are:

- VCG INPUT (frequency modulates the output frequency)
- TRIGGER SYNC (triggers internal circuitry)
- PWM (pulse width modulates the variable output pulse)

The function generator also has the unique feature of containing a sweep generator and a phase-lock‡ control, all in one chassis. Almost any periodic signal can be phase locked from 10 Hz to 10 MHz. The sweep generator can sweep the main frequency from 0.0005 Hz to 10 MHz.

Sweep width is mechanically interlocked to the main frequency dial. The sweep frequency limits, through which the unit is to be swept, are instantly visible on the main frequency dial, via a concentric movable sweep cursor.

A variety of trigger modes provide flexibility of the output waveform. Some of these trigger modes are:

- CONT (permits continuous operation of main generator)
- TRIG (permits internal or external triggering of main generator)
- GATE (inhibits or enables continuous operation)
- TRIG SLOPE/NEG (permits positive or negative triggering slope)
- MAN (manual trigger)

The calibrated frequency range of the function generator is from 0.0005 Hz to 10 MHz in 10 ranges each covering a 20:1 ratio.

‡The Model F54 does not provide the phase-lock feature.

External signals may be applied at the front panel to frequency modulate the main signal output by as much as 100:1. The generator output frequency may be locked to an input reference by applying the external signal to the front-panel TRIGGER SYNC connector.

A total output level variation of greater than 70 db may be realized with the 50 db calibrated step attenuator in combination with the 20 db variable attenuator. Maximum output level is 30 volts peak-to-peak into an open circuit (15 volts p-p into 50 ohms).

Any waveform may be manually offset up to ±10 volts subject to the limitation that the total voltage swing (d-c plus signal peak) may not exceed ±15 volts into an open circuit.

TABLE 1-1. TECHNICAL SPECIFICATIONS

Parameter	Characteristics
Waveforms	
Variable Amplitude	Sinewave Squarewave Triangle wave 15/85% duty cycle positive pulse 15/85% duty cycle negative pulse 15/85% duty cycle positive ramp 15/85% duty cycle negative ramp Sweep sawtooth waveform Variable duty cycle pulses, 5 to 95% of full duty cycle (100 nsec minimum) All waveforms (except negative sweep sawtooth) symmetrical with respect to ground Output impedance: 50 ohms
Simultaneous Fixed Amplitude Monitors	Sine, square (SYNC OUT), triangle, sweep, and sweep sync. Sine, square, and triangle assume 15/85% duty cycle when fixed duty cycle ramps or pulses are selected. All monitors are 2 volts p-p, 50-ohm impedance, balanced with respect to ground except positive-going sweep monitor. SYNC OUT rise time: < 20 nsec.

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Table 1-1. Technical Specifications (Continued)

Parameter	Characteristics
	All monitor signals 180 degrees out of phase with main output. Squarewave (SYNC OUT) leads sine and triangle by 90 degrees.
Frequency	
Range	Sine, square, or triangle waveforms: 0.0005 Hz to 10 MHz. Ramps and pulse waveforms: 0.0005 Hz to 5 MHz. Triggered and gated waveform: 0.0005 Hz to 3 MHz. Ten decade ranges with 50% overlap provide 20:1 continuous vernier adjustment within any range. Sweep is 0.01 Hz to 100 kHz in 7 decade ranges with 10:1 continuous vernier adjustment within any range.
Dial Accuracy	Sine, square, or triangle waveforms: <±1% of setting ±1 minor division, 0.0005 Hz to 500 kHz. <±3% of setting ±2 minor division, 500 kHz to 5 MHz. <±5% of setting ±3 minor division, 5 MHz to 10 MHz. 15/85% duty cycle ramps and pulses: <±1% of setting ±1 minor dial division 0.0005 Hz to 500 kHz. <±10% of setting ±1 minor dial division 500 kHz to 5 MHz.
Stability	<±0.05% of setting for 10 minutes. <±0.25% of setting for 24 hours.

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Table 1-1. Technical Specifications (Continued)

Parameter	Characteristics
Time Symmetry	<1%, 0.0005 Hz to 10 Hz <0.5%, 10 Hz to 100 kHz <2%, 100 kHz to 3 MHz <5%, 3 MHz to 10 MHz
Amplitude	
Attenuator	Precision 2% attenuator calibrated in db and volts peak-to-peak in 10-db steps from 0 db to -50 db (0 db = 10 volts p-p into 50-ohm load). Uncalibrated MAX position provides approximately +3 db maximum output (15 volts p-p). Continuously variable control provides additional 0-db to 20-db attenuation at any step. Minimum output is 70 db below 10 volts p-p (3 mv p-p).
Amplitude Response	Sinewave (Ref: 10 volts p-p (3.5 vrms) into 50-ohms at 1 kHz): <±0.5%, 0.0005 Hz to 100 kHz <±1%, 100 kHz to 1 MHz <±3%, 1 MHz to 5 MHz <± 10%, 5 MHz to 10 MHz Triangle or square waveforms (Ref: 10 volts p-p into 50 ohms at 1 kHz): <±3%, 0.0005 Hz to 1 MHz <± 10%, 1 MHz to 10 MHz Sweep sawtooth waveform: ±1%, 0.01 Hz to 100 Hz ±3%, 100 Hz to 100 kHz

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Table 1-1. Technical Specifications (Continued)

Parameter	Characteristics
Maximum Usable Output* (50-Ohm Load)	Sine, square, or triangle waveforms: >15 volts p-p, 0.0005 Hz to 5 MHz >10 volts p-p, 5 MHz to 10 MHz Ramps and Pulses: >15 volts p-p, 0.0005 Hz to 3 MHz >12 volts p-p, 3 MHz to 5 MHz Sweep sawtooth waveform: 0 to -7.5 volts peak from 0.01 Hz to 100 kHz *With open circuit, maximum output level is twice that specified with 50-ohm load.
Amplitude Differential	P-P differential between sine, triangle, or square waveforms: <5%, 0.0005 Hz to 5 MHz
Rise Times	Squarewave or 15/85% pulses: <30 nsec Variable duty cycle pulses: <50 nsec
Sinewave Distortion (Ref: 10 Vpp into 50 ohms)	<0.5%, 0.0005 Hz to 100 kHz <1.0%, 100 kHz to 1 MHz <3.0%, 1 MHz to 5 MHz <5.0%, 5 MHz to 10 MHz
Triangle Nonlinearity (Ref: 10 Vpp into 50 ohms)	<1%, 0.0005 Hz to 100 kHz <5%, 100 kHz to 5 MHz
Rectangular Wave Aberrations	<5%, 0.0005 Hz to 5 MHz
Amplitude Stability	<±0.05% of specified maximum p-p output for 10 minutes. <±0.25% of specified maximum p-p output for 24 hours.
Offset Stability	<±0.25% of maximum specified p-p amplitude over any 72-hour period.

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Table 1-1. Technical Specifications (Continued)

Parameter	Characteristics
Modulation	
Output Frequency (VCG)	Controlled with an external voltage applied at the VCG INPUT. Linear to within 0.2% on all ranges except 1 M. An input of 0 to +10 volts increases frequency as much as 100:1 from minimum dial setting. An input of 0 to -10 volts decreases frequency as much as 100:1 from maximum dial setting. VCG bandwidth: 100 kHz Input impedance: 10k ohms
Variable Duty-Cycle Pulse Width	Controllable with an external voltage applied at the PWM input (linear to within 1%). With the front panel control (VAR ⎍) centered, 0 to ±10 volts varies duty cycle 5 to 95% (100 nsec minimum). PWM bandwidth: 10 kHz Input impedance: 2k ohms
External Sync Input	Periodic waveforms >5 volts p-p (100-volt maximum) at TRIGGER SYNC input synchronizes the output frequency when within 0 to -1% of the external frequency. (Pulse input waveforms are required at 100k and 1M ranges.) Input impedance: 10k ohms
Sweep	
Continuous	Sweeps the main generator linearly between frequency limits set by frequency dial and sweep limit cursor.

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Table 1-1. Technical Specifications (Continued)

Parameter	Characteristics
	Maximum sweep range: 100:1
	CAL and RESET momentary pushbuttons hold output frequency at high and low sweep limits respectively for exact calibration.
Triggered	Manual or external trigger signal: >±1 volt (100-volt maximum) initiates one sweep cycle.
	Main generator output is on only during sweep interval.
Shift	Main generator operates at frequency dial setting until triggered, then linearly sweeps the output frequency to upper sweep limit and holds until manually reset.
Burst	Any number of main generator waveform cycles (as established by TRIGGER LEVEL control) repetitively triggered by internal sweep generator at rates up to 100k bursts/second.
Phase-Lock‡	Main generator output will automatically phase-lock to the fundamental of any periodic external signal >±1 volt (100-volt maximum) applied to the TRIGGER SYNC input. (Zero Phase Setting)
	Phase between input and output adjustable to ±180 degrees with PHASE control.

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‡The Model F54 does not provide the phase-lock feature.

Table 1-1. Technical Specifications (Continued)

Parameter	Characteristics
	Generator output may be locked to any harmonic or subharmonic through the fifth order of the external frequency by adjusting phase control and observing on scope. Input/Output frequency range: 10 Hz to 10 MHz (with frequency dial set to output frequency between 1.0 and 10). Input impedance: 10k ohms ϕ LOCK indicator lights only when phase-locked to fundamental input frequency.
DC Offset	Selectable (1) 0 volts dc (2) Positive fixed } Peaks tangent to 0 volts dc, output reduced to one-half amplitude (3) Negative fixed } (4) Variable: Adjustable between ±10 volts into an open circuit (signal plus offset is <±15 volts). Variable offset independent of variable attenuator setting only in MAX and 0 db attenuator position.
Trigger	Manual or external signal >±1 volt (100-volt maximum) at TRIGGER SYNC input initiates one complete trigger cycle. Cycle start/stop point continuously variable ±90 degrees with PHASE control TRIGGER LEVEL control and TRIG SLOPE pushbutton determine any triggering point on input waveform. Input Impedance: 10k ohms

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Table 1-1. Technical Specifications (Continued)

Parameter	Characteristics
Gate	Manual or external signal ≥±1 volt (100-volt maximum) at TRIGGER SYNC input gates main generator output on for the duration of the gate signal. Last cycle is completed after gate is removed.
Isolation	Detachable ground strap may be removed to isolate all BNC connectors and circuit grounds from case and power line ground. Maximum isolation: ±500 volts
Operating Temperature	0 to 55°C
Power	115 vac ±10% or 230 vac ±10%, 50 to 400 Hz, 50 watts maximum.

NOTES:

Except where indicated, specifications apply with 25° ±10°C ambient, with 50-ohm resistive load, 0-vdc offset, frequency control set between 1.0 and 10.0 on the frequency dial. All external inputs removed.

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Section II
INSTALLATION

2-1. INTRODUCTION

This section provides instructions pertaining to receiving, inspecting, and installing the equipment.

2-2. RECEIVING AND INSPECTION

Immediately upon receipt of the instrument, the exterior of the shipping container should be inspected for physical damage and the carrier notified if such is visible. After carefully removing all packing materials, the instrument should be inspected to ensure that it is free of all mars and blemishes.

Electrical performance that meets or exceeds the specifications (Section I, table 1-1) should be confirmed as soon as possible. Section V contains a suggested performance test routine and the recommended test equipment.

2-3. INSTALLATION

This instrument may be used on the workbench or rigidly mounted in a RETMA rack structure by means of an optional rack-mounting kit (see figure 2-1 for details of single and double unit rack assemblies). As initially shipped, the instrument is provided with a rugged, adjustable handle that facilitates carrying as well as tilting for optimum panel viewing angle.

This all solid-state instrument requires no special cooling facilities as long as it is operated within the temperature limits specified in table 1-1. Care must be taken to ensure that a minimum of two inches clearance is provided at the rear of the instrument to ensure proper connection cooling of the heatsink.

2-4. POWER REQUIREMENTS

This instrument operates from a-c power only, either 115 or 230 vac, 50 to 400 Hz. A slide switch at the rear of the equipment readily selects the desired power line voltage.

CAUTION

Operation at the wrong power line voltage switch setting may damage the instrument.

A three-conductor cord is supplied with the equipment to permit referencing the chassis and case to power system ground. This safety feature is recommended by the National Electrical Manufacturers Association (NEMA). The offset pin on the power cord connector is the ground wire.

2-5. REPACKAGING

If it becomes necessary to pack the instrument for shipment, the following procedure is recommended.

a. Attach a tag with the owner's name, address, and telephone number together with a

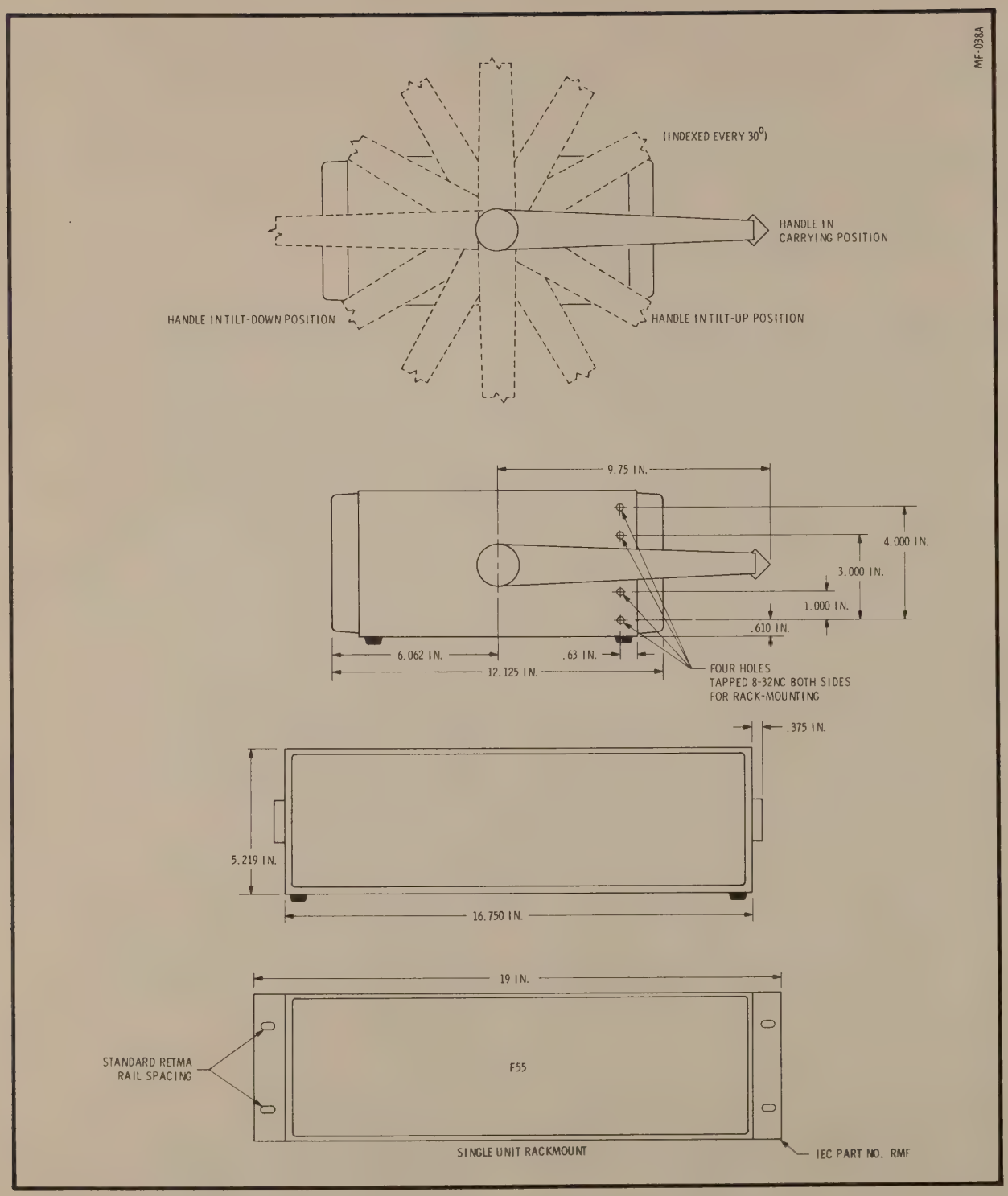


Figure 2-1. Installation Detail

brief description of the purpose of the shipment and the date its return is desired.

b. Wrap the equipment in heavy paper or plastic before placing in an inner container.

c. Use soft packing material liberally around all sides of the instrument inside the inner container.

d. Enclose the inner container in a rugged carton or wood box with suitable packaging material to prevent movement in any direction and seal the outer container with heavy tape or metal bands.

e. Mark the shipping container with the shipping address and "DELICATE INSTRUMENT" labels.

2-6. DISASSEMBLY

To remove the function generator from its case, remove the three retaining screws mounted in the heatsinks at the rear of the unit and one screw from the ground strap and withdraw the chassis through the front of the case.

(1) Remove the four screws (two upper, and two lower) from the top and bottom of the front faceplate (figure 2-2). This will expose the upper and lower front subpanels and controls.

(2) Remove the two retaining screws at the bottom of the A2 board, near the front, outer edges. These screws are seated in two spacers permanently mounted on the A1 board. The A1 and A2 boards, and their respective front subpanels, will then open book-fashion at the front edges.

NOTE

The screw-hinge assembly at the rear of the A2 board is a permanent fixture and need not be dismantled or removed to gain normal access to the boards.

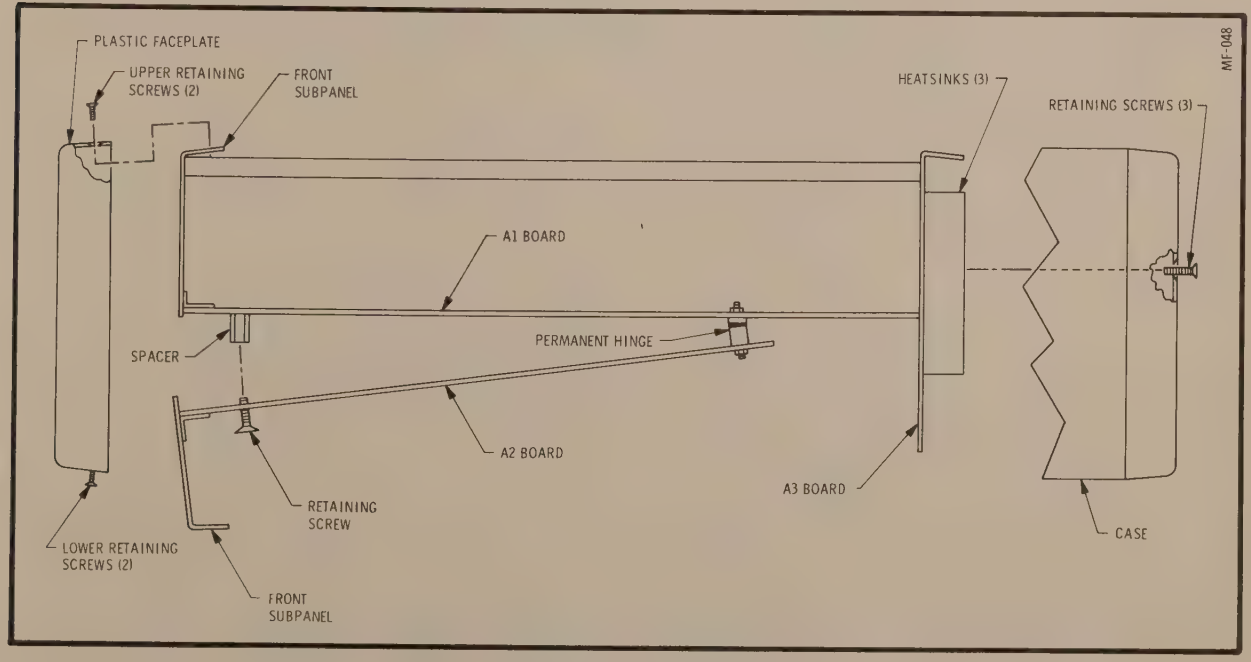


Figure 2-2. Disassembly Diagram

Section III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION

Operation of the function generator is relatively simple and straightforward. Normally, an operator can expect to realize the full potential of the instrument without reference to the manual; however, this section provides operating tips and will assist those unfamiliar with this type of equipment. Refer to figures 3-1 and 3-2 for identification of front and rear panel controls and indicators.

3-2. GENERAL INFORMATION

Power is applied to the function generator by pressing the PWR pushbutton. A neon pilot indicator located at the frequency dial cursor indicates that power is applied to the unit.

Pressing the CONT MODE pushbutton will permit normal output operation of the function generator.

The calibrated 20:1 frequency dial provides a 50 percent overlap with adjacent bands as selected by the MULTIPLIER range switch. The ten decades of the MULTIPLIER switch permit the instrument to be tuned over the frequency range of 0.0005 Hz to 10 MHz.

Any of the nine standard waveforms may be selected with the WAVEFORM switch. The concentric VAR PULSE control (inhibited except when the variable pulse is selected by the WAVEFORM switch) permits varying the duty cycle of a rectangular waveform.

The desired output waveform is provided at the 50 Ω OUTPUT connector.

The OFFSET switch establishes the waveform polarity with respect to ground. The output may be selected to be symmetrical, all positive, all negative, or continuously adjustable about ground. The concentric ADJUST offset control (inhibited except in the ADJ position of the OFFSET switch) provides ±10 volts offset into an open circuit and ±5 volts into a 50-ohm load.

The frequency of the instrument may be varied by an external voltage applied to the VCG INPUT connector on the front panel. A full 100:1 frequency change may be obtained from +10 volts when the frequency dial is set at the low limit, and conversely, from -10 volts with the frequency dial set at the upper limit.

The SYNC OUTPUT signal is a 4 volt p-p open circuit (2 volts p-p into 50 ohms) rectangular wave that, on its positive transition, leads all symmetrical waveforms at main output by 90 degrees. The SYNC OUT signal assumes the same duty cycle as the fixed ramp and pulse outputs; however, for variable pulse width operation, SYNC OUT is 50/50 duty cycle.

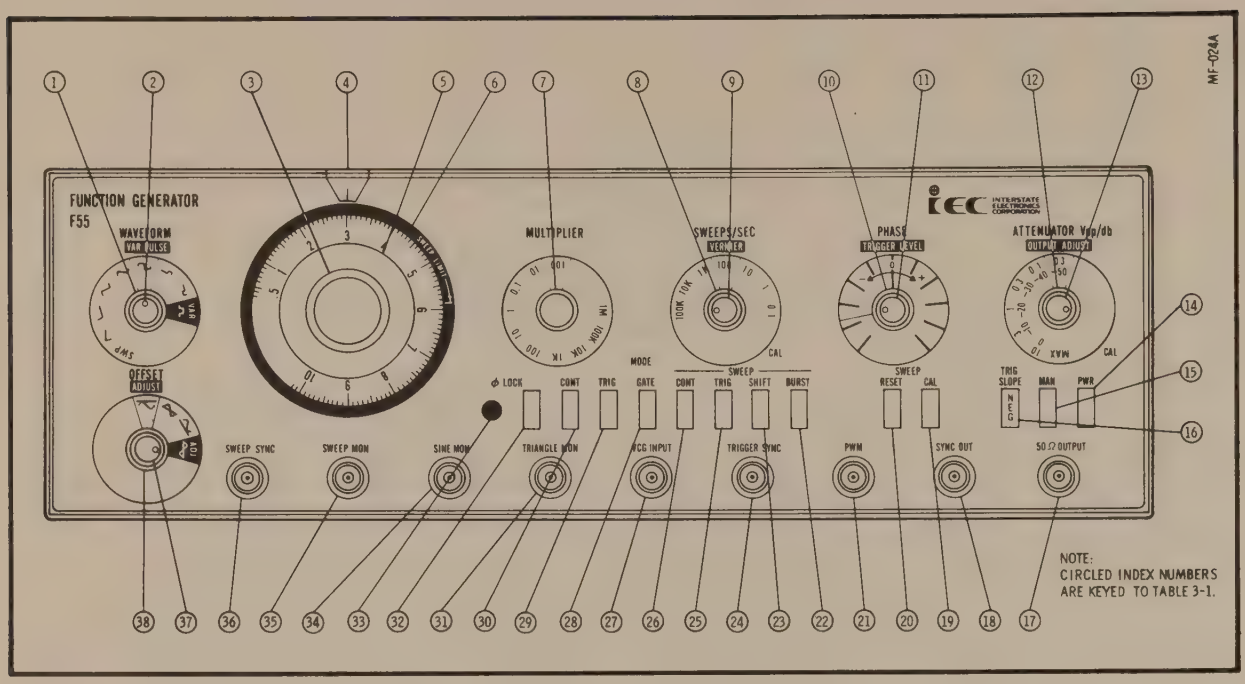


Figure 3-1. Controls and Indicators

TABLE 3-1. FUNCTIONS OF CONTROLS AND INDICATORS

Index No.	Function
1	WAVEFORM switch: Selects desired output waveform; activates VAR PULSE control.
2	VAR PULSE control: Potentiometer varies duty cycle of output pulse when waveform switch is set to VAR ⎍ position.
3	Frequency dial, fine control: Adjusts frequency dial in 6:1 rotation ratio.
4	Dial Cursor/Pilot indicator: Glows when power is applied to the unit.
5	Frequency dial, coarse control: Adjusts frequency dial in 1:1 rotation ratio.
6	SWEEP LIMIT cursor: Cursor sets the high sweep frequency limit.
7	MULTIPLIER switch: Rotary switch selects multiplying factor for frequency setting.
8	SWEEPS/SEC switch: Rotary switch selects sweep generator frequency range.
9	VERNIER control: Potentiometer selects sweep generator frequency.
10	PHASE control: Potentiometer adjusts phase $\pm 180^{O}$ with output waveform when in phase-lock mode; adjusts point (phase) of starting and stopping output waveform when in trigger modes.

Table 3-1. Functions of Controls and Indicators (Continued)

Index No.	Function
11	TRIGGER LEVEL control: Potentiometer selects triggering point on incoming signal to trigger output waveform.
12	ATTENUATOR switch: Rotary switch attenuates the output signal in five steps of 10 db per step. Calibrated in Vpp and db.
13	OUTPUT ADJUST control: Potentiometer provides additional 20 db attenuation of the output amplitude.
14	PWR pushbutton: Power on/off control when power is applied, dial cursor will illuminate.
15	MAN pushbutton: Provides manual input trigger.
16	TRIG SLOPE (NEG) pushbutton: Selects triggering slope of incoming signal; pressed to select negative slope only.
17	50 Ω OUTPUT terminal: Output BNC connector for all waveforms. Maximum output level is 30 volts p-p (open) or 15 volts p-p (into 50 ohms).
18	SYNC OUT terminal: Output BNC connector provides rectangular waveform 180^{O} out of phase with the 50 Ω OUTPUT squarewave signal. (2 volts p-p into 50 ohms.)
19	SWEEP CAL pushbutton: Provides maximum sweep output frequency.
20	SWEEP RESET pushbutton: Resets sweep generator when in SHIFT mode and provides zero sweep output frequency.
21	PWM terminal: Input BNC connector for modulating the output pulse width when VAR ⎍ waveform is selected.
22	SWEEP BURST pushbutton: Provides (variable number of) cycles of selected WAVEFORM output by adjusting trigger level.
23	SWEEP SHIFT pushbutton: Provides one cycle of the sweep generator and holds main generator at maximum frequency.
24	TRIGGER SYNC terminal: Input BNC connector synchronizes output waveform with input in CONT or Φ LOCK‡ MODES. Provides trigger input signal to trigger the sweep generator when in SWEEP TRIG, SWEEP SHIFT, or SWEEP BURST MODES. Provides trigger input signal to trigger the output waveform when in TRIG or GATE MODE.
25	SWEEP TRIG pushbutton: Allows TRIGGER SYNC input signal to trigger the sweep generator.
26	SWEEP CONT pushbutton: Provides continuous operation of the sweep generator. generator.

‡The Model F54 does not provide the phase-lock feature.

Table 3-1. Functions of Controls and Indicators (Continued)

Index No.	Function
27	VCG INPUT terminal: BNC connector provides for external voltage control of the output frequency.
28	GATE MODE pushbutton: Allows TRIGGER SYNC input signal to enable the main output waveform.
29	TRIG MODE pushbutton: Allows TRIGGER SYNC input signal or MAN pushbutton to trigger one cycle of the main output waveform.
30	CONT MODE pushbutton: Provides for selection of continuous operation of the main output waveform.
31	TRIANGLE MON terminal: BNC connector provides auxiliary triangle output waveform (2 volts p-p into 50 ohms).
32	ϕ LOCK pushbutton‡: Allows output waveform frequency to track input TRIGGER SYNC frequency.
33	ϕ LOCK indicator‡: Glows when output frequency is locked to fundamental frequency of TRIGGER SYNC.
34	SINE MON terminal: BNC connector for auxiliary sinewave output (2 volts p-p into 50 ohms).
35	SWEEP MON terminal: BNC connector for auxiliary sweep output waveform (2 volts p-p into 50 ohms, 0-vdc baseline).
36	SWEEP SYNC terminal: BNC connector for narrow sweep sync output pulse (2 volts p-p into 50 ohms).
37	ADJUST (OFFSET) control: Potentiometer provides continuously variable d-c offset when OFFSET switch is in the ADJ ∿ position.
38	OFFSET switch: Rotary switch selects waveform offset with respect to ground. Positive and negative going functions are half amplitude as compared to functions symmetrical about ground.

‡ The Model F54 does not provide the phase-lock feature.

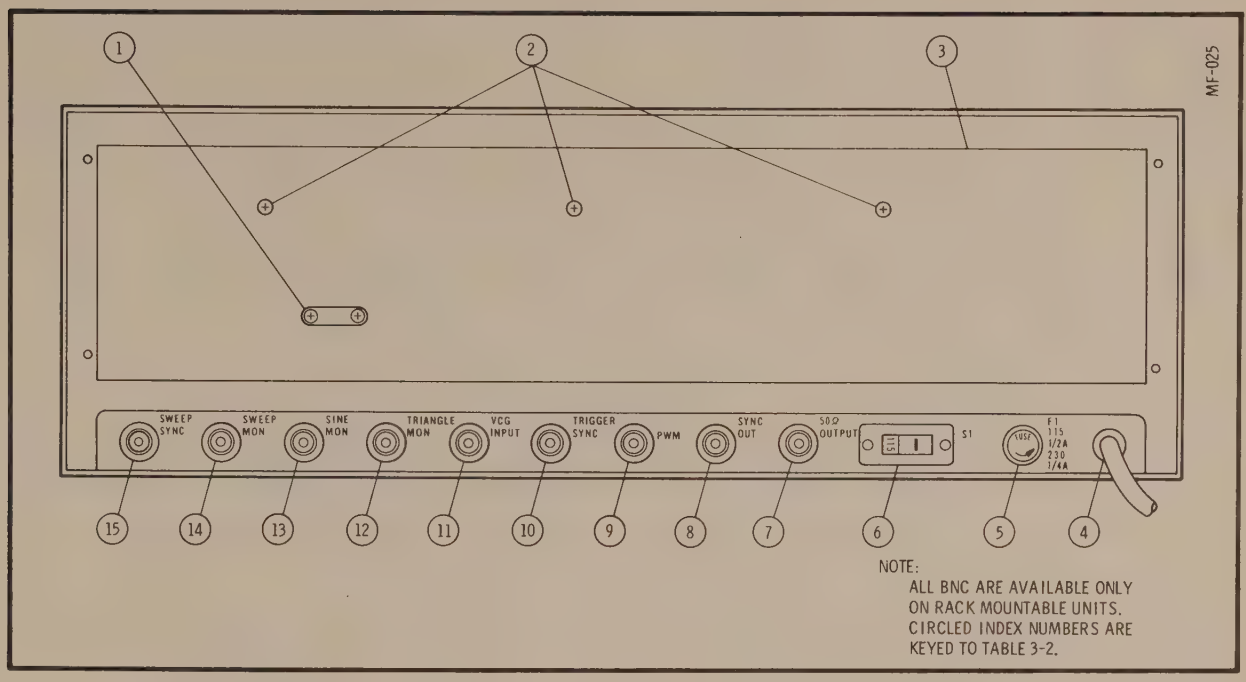


Figure 3-2. Real Panel Connectors and Fuse

TABLE 3-2. FUNCTIONS OF REAR PANEL CONNECTORS AND FUSE

Index No.	Function/Description
1	Ground Strap: Permits signal ground to be isolated from case ground.
2	Retaining Screws: Mounted in heatsinks: remove to dismantle the unit.
3	Rear Panel: Primary heatsink for power supply.
4	Line Cord: Three-wire type cord permits grounding of case.
5	Fuse: Slo-Blo, 1/2 Amp. 115 VAC; 1/4 Amp. 230 VAC.
6	Line Voltage Switch: Selects 115 VAC or 230 VAC.
7	50 Ω OUTPUT terminal: Output BNC connector for all waveforms. Maximum output level is 30 volts p-p (open) or 15 volts p-p (into 50 ohms).
8	SYNC OUT terminal: Output BNC connector provides rectangular waveform 180^{o} out of phase with the 50 Ω OUTPUT squarewave signal (2 volts p-p into 50 ohms).
9	PWM terminal: Input BNC connector for modulating the output pulse when VAR waveform is selected.
10	TRIGGER SYNC terminal: Input BNC connector synchronizes output waveform with

Table 3-2. Functions of Rear Panel Connectors and Fuse (Continued)

Index No.	Function/Description
10	TRIGGER SYNC terminal: Input BNC connector synchronizes output waveform with input signal when in CONT MODE. Provides trigger input signal to trigger the sweep generator when in SWEEP TRIG, SWEEP SHIFT, or SWEEP BURST MODES. Provides trigger input signal to trigger the output waveform when in TRIG or GATE MODE.
11	VCG INPUT terminal: BNC connector provides for external voltage control of the output frequency.
12	TRIANGLE MON terminal: BNC connector provides auxiliary triangle output waveform (2 volts p-p into 50 ohms).
13	SINE MON terminal: BNC connector for auxiliary sinewave output (2 volts p-p into 50 ohms).
14	SWEEP MON terminal: BNC connector for auxiliary sweep output waveform (2 volts p-p into 50 ohms, 0-vdc baseline).
15	SWEEP SYNC terminal: BNC connector for narrow sweep sync output pulse (2 volts p-p into 50 ohms).

3-3. OPERATING INFORMATION

The SWEEPS/SEC switch controls the frequency of an independent, internal sweep generator. Various pushbutton-selectable modes control the functions of the sweep circuitry.

The SWEEP CONT pushbutton enables the sweep oscillator and generates a waveform at the SWEEP MON and SWEEP SYNC terminals. When SWP is selected at the WAVEFORM switch, a zero to -15 volt (open) sweepwave is provided at the 50 Ω OUTPUT terminal. The black SWEEP LIMIT cursor (concentric around the main frequency dial) controls the highest frequency of the main generator that can be swept by the sweep generator.

The SWEEP TRIG pushbutton disables the sweep generator until a trigger pulse is received at the TRIGGER SYNC terminal. The TRIGGER LEVEL control is used to determine the precise point of triggering.

The SWEEP SHIFT pushbutton provides a sweep and hold operation, whereupon the trigger input signal triggers one sweep cycle and holds the sweep output at its maximum level. The main generator frequency sweeps to the high limit as indicated by the SWEEP LIMIT cursor and remains at the frequency until reset by pressing the RESET pushbutton.

Pressing the SWEEP BURST pushbutton allows one or more cycles of the main generator to be triggered from the sweep generator. Thus, the cycle groups are produced at the repetitive SWEEPS/SEC rate.

A single-cycle mode is obtained by pressing both the SWEEP BURST and TRIG MODE pushbuttons to trigger one cycle of the main frequency for every cycle of the sweep frequency.

Pressing the SWEEP RESET pushbutton unlocks the sweep generator from the sweep and hold (SHIFT) mode by disabling it and setting a minimum level for the sweep waveform.

The SWEEP CAL pushbutton facilitates calibration and measurement of the highest frequency to be swept on the main frequency by inserting a fixed voltage level on the sweep generator output.

NOTE

The SWEEP CAL and SWEEP RESET pushbuttons are both direct inputs and bypass all other sweep controls and switches.

The PHASE control performs a dual function: (1) when in the ϕ LOCK MODE,‡ the PHASE control varies the output phase ±180 degrees relative to the input phase, and (2) when in TRIG or GATE MODE the PHASE control determines the starting point (phase) of the first cycle and the stopping point of the last cycle.‡

The TRIGGER LEVEL control determines the exact point on the TRIGGER SYNC input signal needed to trigger the internal logic.

The TRIG SLOPE (NEG) pushbutton, when pressed, will select the negative edge of the TRIGGER SYNC input signal; otherwise, it selects the positive edge.

Pressing the CONT MODE pushbutton provides continuous operation of the main function generator frequency and allows all waveforms to be available at the 50 Ω OUTPUT terminal, except for SWP (sweep).

Pressing the TRIG MODE pushbutton disables the main frequency until a TRIGGER SYNC input signal is received or until the MAN (manual trigger) pushbutton is pressed. Only one cycle of the main output frequency is produced per one trigger cycle.

Pressing the GATE MODE pushbutton also disables the main frequency until a TRIGGER SYNC input signal is received or until the MAN (manual trigger) pushbutton is pressed; however, in GATE MODE, the output frequency operation continues for the duration of the gate signal.

Pressing the ϕ LOCK MODE ‡ pushbutton allows the output frequency to track any periodic TRIGGER SYNC input signal. The output frequency can be phase-locked to any periodic input signal from 10 Hz to 10 MHz when within the proper frequency range controls on the front panel. The phase-lock circuitry is capable of locking onto harmonics (up to the fifth) and subharmonics (down to the fifth) while observing the input and output on an oscilloscope. However, the ϕ LOCK indicator will only illuminate when the output generator frequency is identical to the TRIGGER SYNC input frequency.‡

The ATTENUATOR Vpp/db switch is a 50 db (calibrated 10 db per step) attenuator from 10 volts p-p to 0.03 volts p-p, with a 20 db continuously variable OUTPUT ADJUST control.

‡The Model F54 does not provide the phase-lock feature.

The MAX position on the face of the ATTENUATOR switch is not calibrated but provides 30 volts p-p (open) or 15 volts p-p (into 50 ohms). A total of 70 db attenuation can be achieved by the combined function of both attenuator controls.

CAUTION

Disconnect any external input to the TRIGGER SYNC terminal when not in use so that waveforms are not perturbed by accidental TRIGGER SYNC input signals.

3-4. OPERATING TIPS

a. FREQUENCY MODULATION. - Any output frequency may be frequency modulated up to a 100 kHz rate with an a-c signal of peak-to-peak value less than 10 volts.

b. OFFSET. - The sum of the d-c offset plus the signal peak value can not exceed ±15 volts into an open circuit (±7.5 volts into 50 ohms).

c. PULSES AND RAMPS. - The extremely fast rise times and slew rates of the function generator circuitry permit practical pulse durations of less than 100 nanoseconds. However, pulse and ramp waveforms above 5 MHz (200 nsec period) will experience degradation with increasing frequency. The fastest possible rise times (less than 20 nanoseconds) are available at the SYNC OUT terminal because of the reduced, fixed amplitude. It will be noted that the nature of the variable pulse-width circuits causes a variable delay between the SYNC OUT and the 50 OUTPUT waveform as the pulse width is adjusted.

d. WAVEFORM PURITY. - The 50 percent frequency overlap of adjacent ranges will often make it possible to tune to the desired frequency on either of two MULTIPLIER ranges. Select the lower MULTIPLIER range for maximum waveform purity.

e. SINGLE-CYCLE MODE. - The sweep generator can be used as an internal trigger generator for the main frequency by pressing both the TRIG MODE and the SWEEP BURST pushbuttons.

f. SWEEP (SWP) OUTPUT. - An output sweep waveform can only be obtained by pressing the SWEEP CONT pushbutton with the WAVEFORM switch set at SWP. The waveform is zero to -15 volts, controlled by the output ATTENUATOR, at the 50 Ω OUTPUT terminal.

g. PWM INPUT. - PWM input remotely controls the pulse width of the output pulse when the WAVEFORM switch is set in the VAR ⎍ position.

h. TRIGGER SLOPE. - The TRIG SLOPE (NEG) pushbutton is pressed only when the negative triggering edge is desired; otherwise the positive edge is used for the trigger input.

i. SWEEP LIMIT. - The black SWEEP LIMIT cursor, concentric around the outer edge of the frequency control, permits easy setting of the upper sweep frequency of the main frequency. Thus, the main frequency will sweep from the frequency indicated on the dial to the frequency limit set on the SWEEP LIMIT cursor.

Section IV
THEORY OF OPERATION

4-1. INTRODUCTION

This section contains a detailed functional description of the function generator. Each functional section is discussed with its own block diagram to facilitate easy understanding.

4-2. OVERALL FUCTIONAL DESCRIPTION

The complete block diagram is shown in figure 4-1. This diagram illustrates the interrelationships of all of the functional sections which are discussed in the following paragraphs. A more detailed block diagram is shown in figure 7-1, and circuit board detailed schematics are shown in figures 7-3, 7-5, and 7-7.

The function generator can be divided into 13 functional sections. Each of these is explained in a logical progression:

- Frequency Control
- Voltage-to-Current Converter
- Triangle Amplifier
- Inverter Amplifier
- Automatic Level Control
- Voltage Level Sensor
- Sine Shaper
- Variable Pulse Width Shaper
- Output Amplifiers
- Trigger Logic
- Phase Lock Control‡
- Sweep Generator
- Power Supply

4-3. FREQUENCY CONTROL AND VOLTAGE-TO-CURRENT CONVERTER

The frequency control section makes up the "front end" of the function generator. Inputs are single-ended control voltages from the main frequency potentiometer or from an external voltage source. The voltages are scaled, inverted, and offset by the frequency control circuits.

The voltage-to-current converter interfaces with four related output voltages from the frequency control section. By means of precision resistor networks and closed-loop amplifiers, these voltages are converted to proportional, equal and opposite, switchable currents. The currents, of appropriate magnitude, when switched into an integrating capacitor, under controlled conditions, determine the frequency of the function generator.

Figures 4-2 and 4-3 show the essential elements of the frequency control and voltage-to-current converter circuits in block diagram form.

a. FREQUENCY CONTROL. - As shown in figure 4-2, two controlling voltages (from the main frequency dial control or from an external source, if used) are summed at the input to the first inverting amplifier. A fixed, positive

‡The Model F54 does not provide the phase-lock feature.

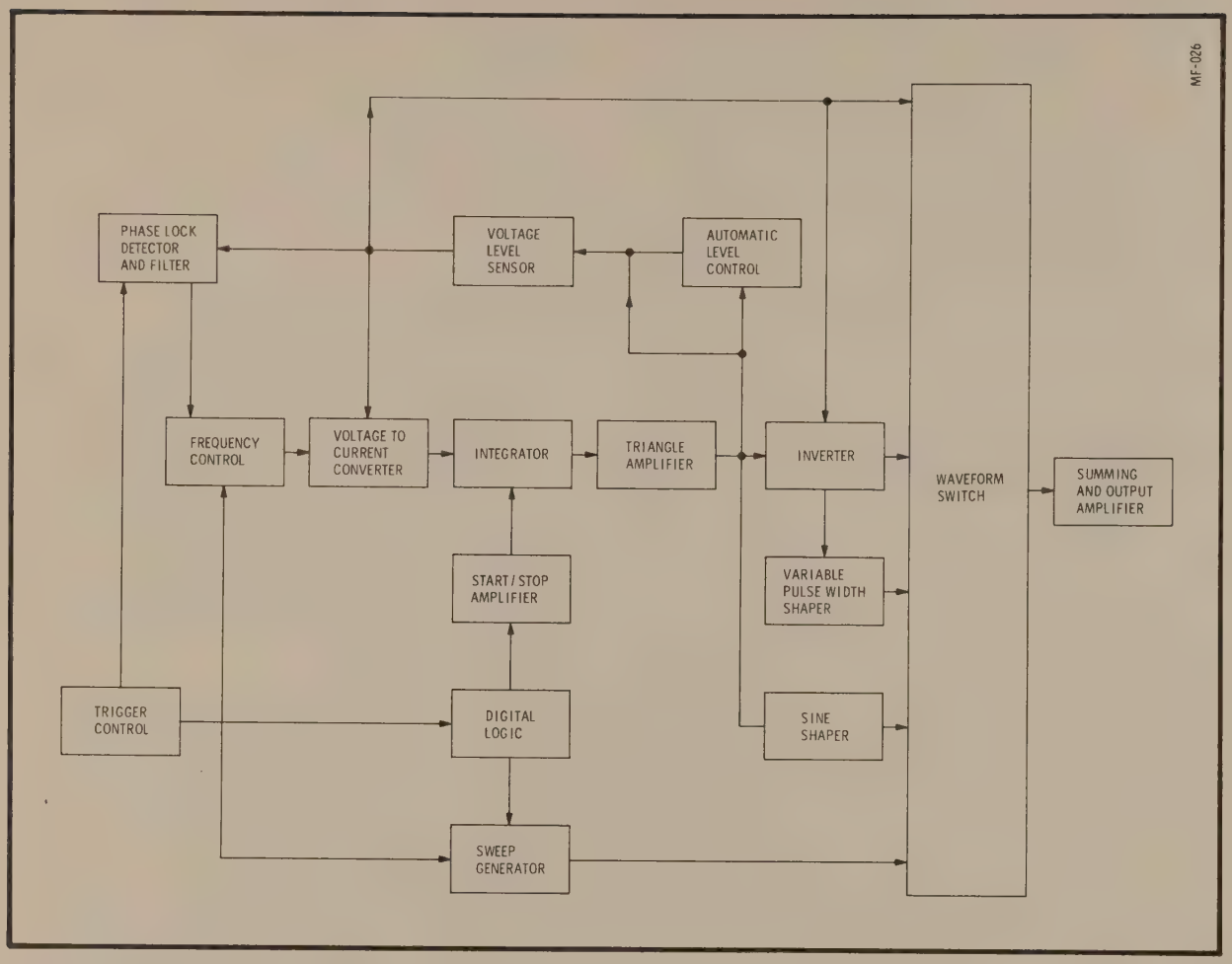


Figure 4-1. Simplified Block Diagram

level offset voltage is also summed at the same point. Full frequency control range, represented by a zero to +10 volts excursion at the input, becomes an offset -7.5 volts to -17.5 volts excursion at V_B, the output of the first inverting amplifier. The second inverting amplifier furnishes an equal but opposite voltage, V_A, exhibiting an excursion between +7.5 and +17.5 volts. The fixed voltages V_C and V_D are established as references. The subsequent section will utilize the terms (V_A - V_C) and (V_B - V_D) in converting to a zero current reference. Summation of V_C and V_D at the + input to the second inverting amplifier causes the terms (V_A - V_C) and (V_B - V_D) to track power supply variations proportionally.

In the following detailed analysis of the frequency control section refer to the schematic, figure 7-3. The setting of the main frequency control A1-R3 establishes a voltage at A1-TP1 between 0 and +10 volts. This voltage is calibrated by adjustable resistor A1-R1 for a midrange frequency. Other frequency ranges are calibrated by resistors A1-R4, A1-R6, and A1-R368. Resistive summing via

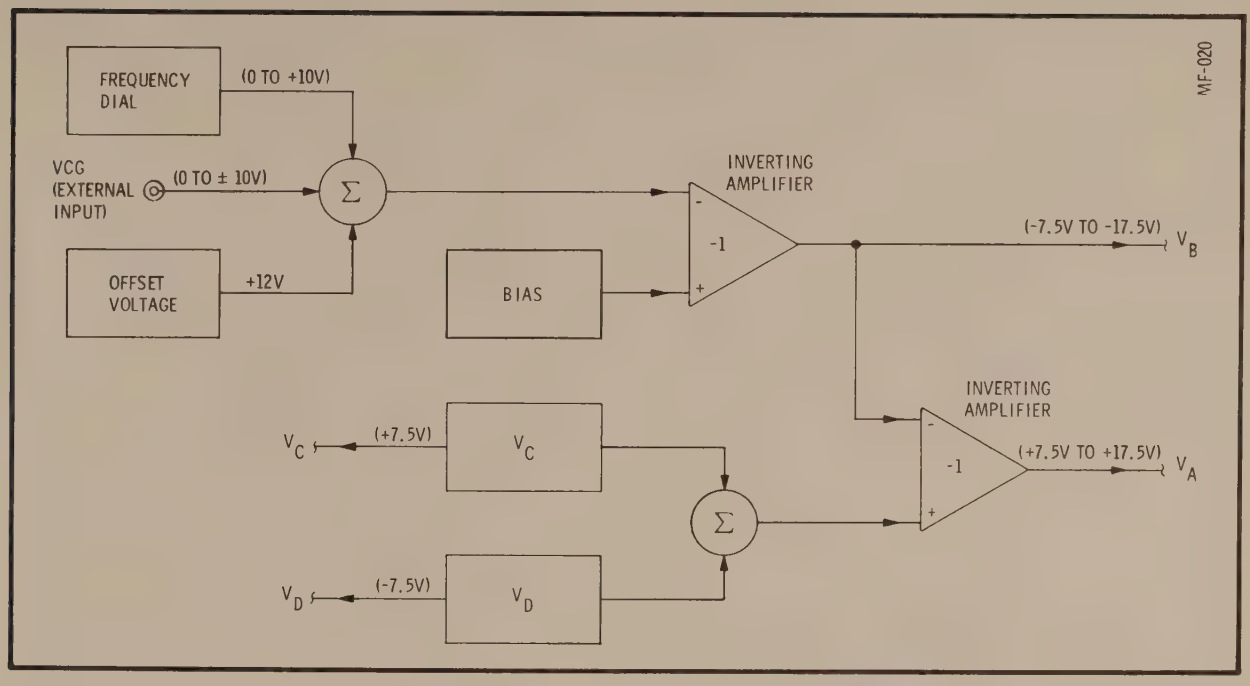


Figure 4-2. Frequency Control, Block Diagram

A1-R7, A1-R9, and A1-R10 combines the main frequency control voltage with an offset derived from +12 volts, and with an external voltage when used in a voltage controlled generator (VCG) mode. Operational amplifiers A1-IC1 and A1-IC2 develop the negative control voltage V_B and the inverted positive control voltage V_A respectively. The range of operation of V_A is +7.5 to +17.5 volts, and V_B from -7.5 to -17.5 volts. A resistive divider network derives nominal ±7.5 volt reference voltages V_C and V_D from the ±12 volt power supplies. Potentiometer A1-R28 is employed as a symmetry adjustment for obtaining 50/50 duty cycle waveforms.

b. VOLTAGE-TO-CURRENT CONVERTER. - With reference to figure 4-3, the voltage difference terms (V_A - V_C) and V_B - V_D) are impressed across the ramp and range resistive networks. The differencing is mechanized by means of operational amplifiers connected as voltage followers. Field effect transistors at the follower outputs serve to translate the voltages to currents i_A and i_B between the differing voltage levels at the follower and at the diode bridge current-steering switch. Alternate charging and discharging of the selectable integrating capacitors at the diode bridge output, under control of the squarewave, results in the desired triangular waveform.

The ramp and range networks are series-parallel combinations of resistors which determine the magnitude of currents i_A and i_B in accordance with control voltages (V_A - V_C and (V_B - V_D), the selected frequency range and either a symmetrical 50/50 duty cycle or a 15/85 ramp. For 50/50 duty cycle operation, the series ramp network at V_A is shorted out, and the parallel network at V_B is opened. When a ramp function has been selected, the

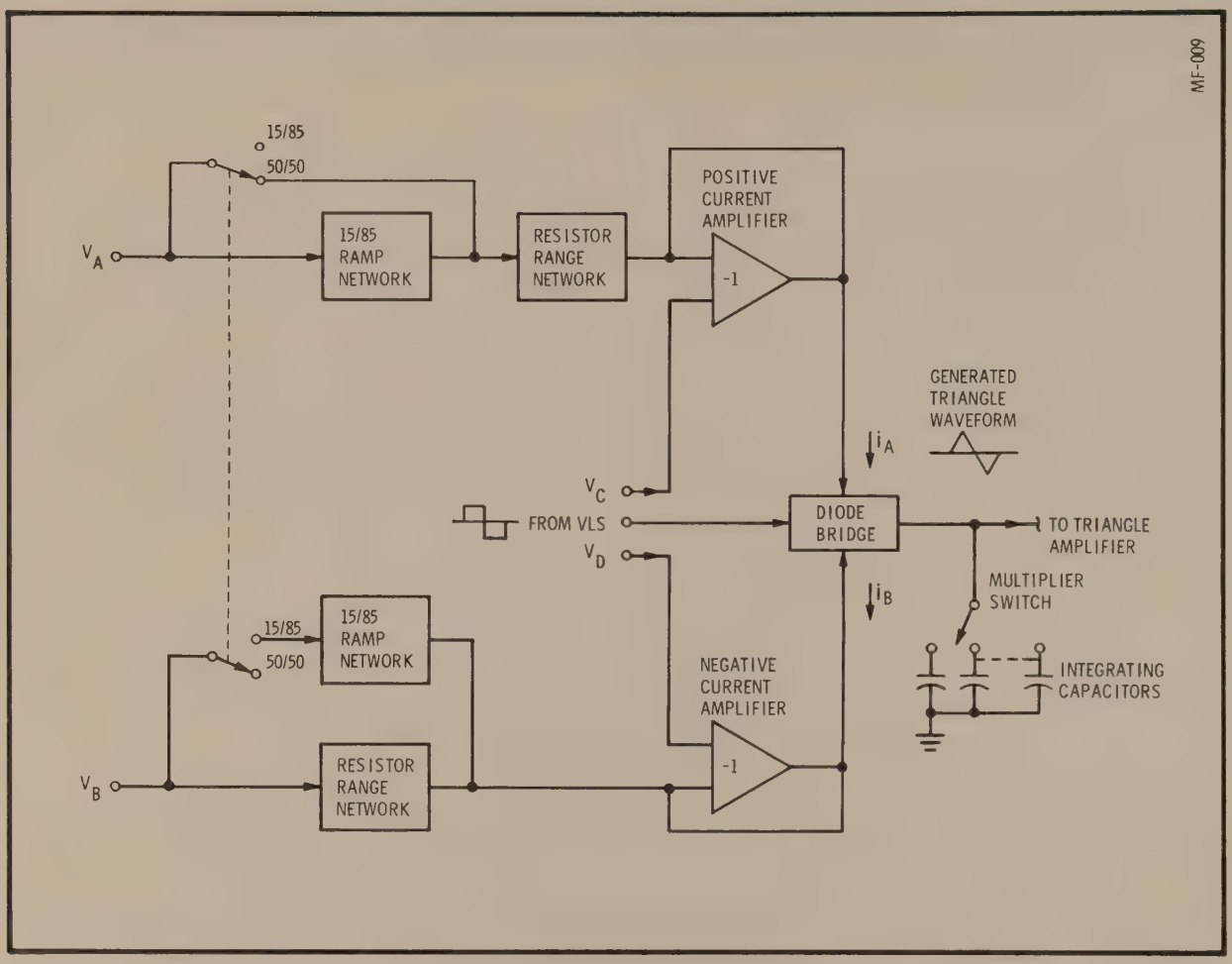


Figure 4-3. Voltage-To-Current Converter, Block Diagram

insertion of the series network reduces i_A by approximately 40 percent and the connection to the parallel network increases i_B to 333 percent. This satisfies the conditions necessary to generate the required voltage ramps at the integrating capacitors.

In the following detailed analysis of the voltage-to-current converter, refer to the schematic, figure 7-3. Voltages V_A and V_C are impressed across the MULTIPLIER switch network A1-R32 through A1-R40. The resultant current flow is dependent upon both the MULTIPLIER setting and WAVEFORM selection. Similarly, an opposite polarity current is developed by the network A1-R41 through A1-R49. The relationship between the two opposite polarity currents is modified by the WAVEFORM switch in accordance with the 15/85 duty cycle capability, by means of series network A1-R50, A1-R51, A1-R53 through A1-R57, and parallel network A1-R58 through A1-R65. When these networks are inserted, the resultant current from V_A is reduced to 50/85 of nominal, and the current from V_B is increased to 50/15 of nominal. The resultant integrator waveform

exhibits a 15/85 duty cycle, with negligible shift of frequency from the nominal 50/50 condition.

(1) Integrated circuit amplifiers A1-IC3 and A1-IC4 form the basis for active current sources. Because of the wide range of currents to be accommodated (approximately 2 na to 25 ma), field-effect buffers are required at input and output. The resultant performance approaches an ideal current source at low frequencies (<100 kHz) because of the high voltage gain of the amplifiers. At high frequencies (>100 kHz) the intrinsic output impedance of transistors A1-Q7 through A1-Q10 gives less perfect, but adequate, approximations to current source operation.

(2) Diodes A1-CR1 through A1-CR8 make up a current-steering bridge. When A1-TP7 is low (-3 volts), curent will flow toward that test point from the upper (positive) current source. The lower (negative) current source will then accept current from the integrating capacitor through diodes A1-CR5 and A1-CR6. When A1-TP7 goes high (+3 volts), currents will interchange via the bridge. Note the use of two series diodes in each leg of the bridge. This is necessary because of the conflicting requirements of low leakage and low stored charge at extremes of the function generator frequency range. These characteristics are not obtainable to the required degree in a single diode.

(3) Integrating capacitors A1-C29 through A1-C34 are selected in accordance with the desired MULTIPLIER switch setting. The highest frequency range incorporates an adjustable capacitor for purposes of frequency calibration.

4-4. TRIANGLE AND INVERTER AMPLIFIERS

The triangle amplifier is a wideband, potentiometric, gain-of-four amplifier. Its purpose is to buffer the integrating capacitor as well as to furnish a low-impedance 6-volt p-p signal for succeeding circuitry. The inverting amplifier is of similar design, except that it is connected as a gain-of-minus-one amplifier to supply an inverted waveform with respect to the triangle amplifier output. The inverted waveform is utilized for reversed polarity ramp and pulse functions.

The block diagram, figure 4-4, indicates the input/output relationship of the triangle and inverter amplifiers. The configuration is quite conventional. A major consideration is the potentiometric configuration of the triangle amplifier for obtaining extremely high input impedance. Not shown in the block diagram, but essential for the low-frequency ranges of the function generator, is the low-input-current, dual field-effect transistor A1-Q11.

a. TRIANGLE AMPLIFIER. - Field effect transistor A1-Q11 is connected as a source follower, driving the differential transistor array A1-IC5A. Because of the wideband requirements of the amplifier, A1-IC5 incorporates high-frequency transistors (f_T >1000 MHz). Again, in order to maintain wideband response, the output A1-IC5A is coupled through common-base amplifier A1-Q12 to the complementary emitter-follower output drivers A1-Q13 and A1-Q14. A1-Q65 provides a current source for the common base drive A1-Q12. The triangle monitor output is power boosted by the drivers A2-Q58 and A2-Q59. DC feedback is applied via A1-R91 and A1-R92, establishing a voltage gain of four with A1-R367 for calibration. High-frequency feedback is coupled with A1-C38, which is adjustable for purposes of shaping overall high-frequency response.

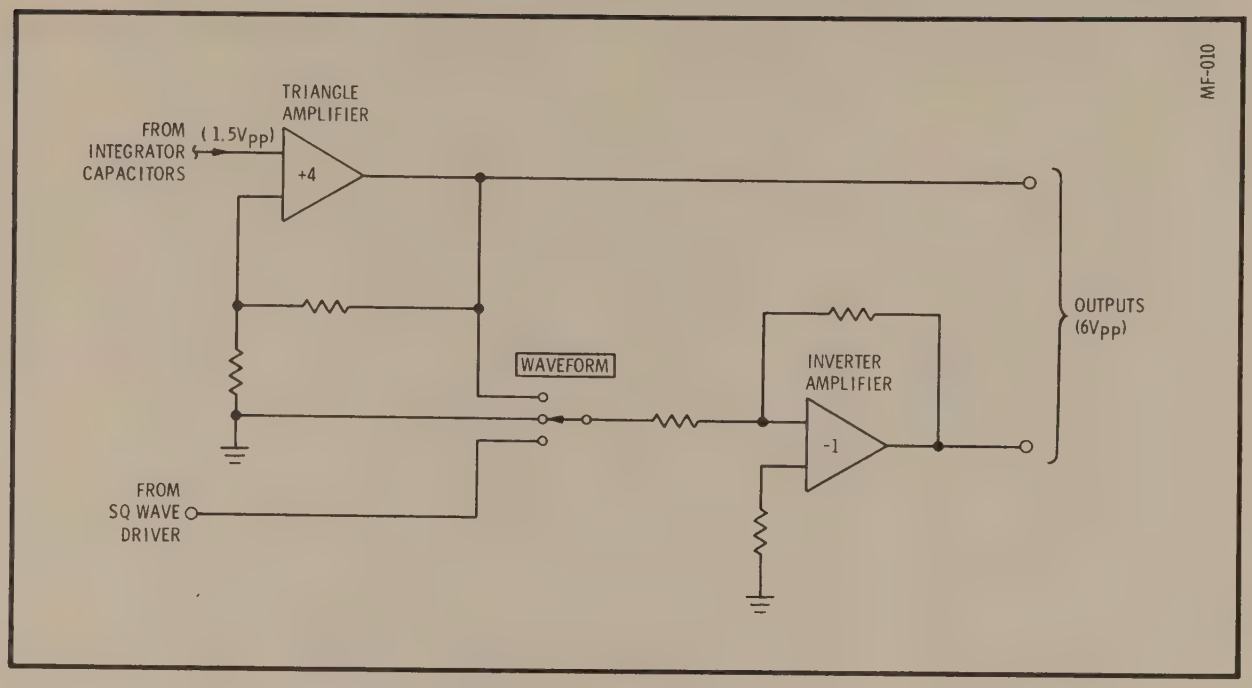


Figure 4-4. Triangle and Inverter Amplifier, Block Diagram

b. INVERTER AMPLIFIER. - Essentially identical design approach is employed as for the triangle amplifier, except that the inverter amplifier is simplified by elimination of the field-effect transistor input. The circuit shares one-half of array A1-IC5 and d-c biasing networks with the triangle amplifier. Feedback resistors A1-R105 and A1-R115 establish a nominal gain of minus one.

4-5 VOLTAGE LEVEL SENSOR AND AUTO — MATIC LEVEL CONTROL OPERATION

The combined function of the VLS-ALC circuits is one of determining the point at which the main integrator ramp is caused to reverse slope. (Refer to the block diagrams, figures 4-5 and 4-6.) The VLS is essentially an ultra-fast comparator, referenced to a pair of adjustable d-c positive and negative reference levels.

The ALC is necessary on the highest frequency range only as a means for loop delay compensation. Together, the VLS and ALC form a peak amplitude regulator, with the error signal being the difference between a fixed d-c reference voltage and the peak (rectified) output of the triangle amplifier. In turn, the amplified error signal becomes a variable reference level to the VLS. Should the triangle amplifier peak amplitude vary from its established value, the resultant error signal will automatically cause the VLS comparison level to shift in the proper direction for a reduced error.

Note that the TRIGGER SYNC input signal also drives the VLS. Sync circuits provide for frequency-locking the function generator to an external source of sync pulses. Synchronization is achieved whenever a sync input

pulse occurs within a period of 0 to -1 percent of the triangle peak. In essence, this implies that the sync pulse frequency (or a harmonic thereof) must be within 0 to +1 percent of the frequency established by the free-running function generator. The sync function is implemented by a transistor switch which causes a periodic reduction of 1 percent in the d-c reference level to the VLS.

a. VOLTAGE LEVEL SENSOR. - The VLS (figure 4-5), accepts a bidirectional ramp voltage waveform, and by means of two difference amplifiers, compares the input waveform against positive and negative reference levels. As the ramp input approaches V_R (+), the output current from the positive difference amplifier increases. When the positive tunnel-diode current reaches its characteristic "peak point," it will trigger on. The increased voltage drop across the on diode is coupled through an inverting driver to reset the current mode latch. (The reset condition of the latch is defined as a negative output voltage level with respect to ground.)

The bias feedback amplifier senses the state of the latch and feeds back conditioning levels to the tunnel diode circuits. The need for this feedback is dictated by the requirement for minimal recovery time.

As the input ramp approaches V_R(-), the output current from the negative difference amplifier increases, causing the negative tunnel diode to trigger on. An inverting driver in turn will set the current mode latch. The cycle is completed as the bias feedback amplifier again changes state in response to the toggling of the latch.

In the following more detailed discussion, refer to the schematic diagram, figure 7-2.

(1) DIFFERENCE AMPLIFIERS. - Transistor arrays A1-IC12 and A1-IC13 accept the integrator ramp waveform and reference levels V_R (+) and V_R (-). As the positive-going input voltage (A1-TP14) approaches V_R (+) (A1-TP17), there is an increased current flow at pin 12 of IC4. This current flow adds to the bias current of tunnel diode A1-CR40. When $e_{in} \approx V_R$ (+), total current will be sufficient to fire A1-CR40, causing an increased voltage drop across the diode. This voltage increase will be sufficient to turn on A1-Q51.

(2) CURRENT-MODE LATCH. - The transistor pair A1-Q53 and A1-Q54 forms a current-mode latch, so that the turn-off of A1-Q54 causes the turn-on of A1-Q53. As A1-Q54 turns off, its collector drops towards the -3 volt zener clamp level established by A1-CR54. The A1-Q54 collector level is coupled through driver transistors A1-R29, A1-Q57 and A1-Q58 to the VLS squarewave output A1-TP7.

(3) BIAS FEEDBACK AMPLIFIER. - Transistor pair A1-Q61 and A1-Q62 is a differential pair connected to provide a bias feedback function. When A1-Q54 goes off, it also turns off A1-Q62 (and turns on A1-Q61). The immediate effect is the reverse biasing of tunnel diode A1-CR40, and also causing tunnel diode A1-CR60 to be forward biased slightly below its firing current level. Potentiometer A1-R258 is provided to adjust the drive signal for optimum settling of the switched currents.

(4) RAMP REVERSAL. - Once diode A1-CR40 has fired, the input voltage ramp

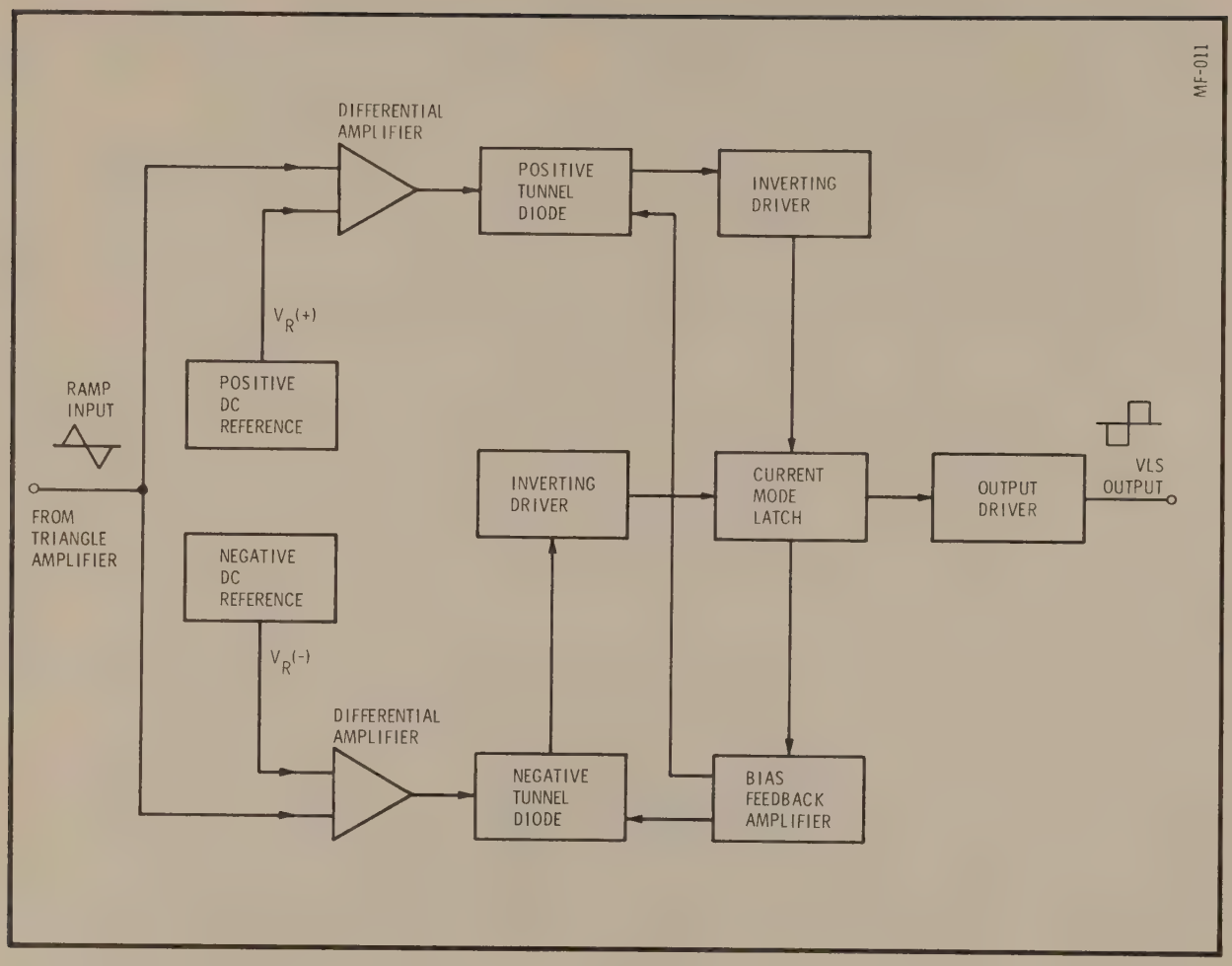


Figure 4-5. Voltage Level Sensor, Block Diagram

will reverse to become negative-going. As this ramp approaches V_R (-) A1-TP19, there is an increased current flow at pin 5 of A1-C13. This current flow adds to the bias current of tunnel diode A1-CR60. When $e_{in} \approx V_R$ (-), total current will be sufficient to fire A1-CR60. The firing of A1-CR60 will cause A1-Q60 to turn on, toward +12 volts. This rise of voltage is transmitted through A1-CR68 to reverse bias A1-Q53. Latch A1-Q53 and A1-Q54 reverses state, causing the output to change from -3 volts to +3 volts.

Following the reverse biasing of A1-Q53, bias current transfers from A1-Q61 to A1-Q62 in turn causing the reverse biasing of A1-CR60 and the partial forward biasing of A1-CR40.

At this point, the input ramp reverts to positive-going and the previously described sequence of events is repeated.

b. AUTOMATIC LEVEL CONTROL AND COMPENSATED LEVEL CONTROL. - The ALC is necessary on the highest frequency range

only as a means for loop delay compensation. Without the ALC, the main loop performance would be severely limited at the high-frequency end because of the effect of propagation time around the loop (≈25 ns). Together, the VLS and ALC form a peak amplitude regulator, with the error signal being the difference between a fixed d-c reference voltage and the peak (rectified) output of the triangle amplifier. In turn, the amplified error signal becomes a variable reference level to the VLS. If the triangle amplifier peak amplitude varies from its established value (because of integrator loop delay of≈25 ns), the resultant error signal will automatically cause the VLS comparison level to shift in the proper direction for a reduced error.

The primary ALC loop has the characteristic of a relatively long time constant, because of the need for rectifying and filtering of the control signal. The effect of this time constant is to degrade performance in response to fast sweep waveforms. The compensated level control (CLC) circuits are intended as a first order correction to overcome the effect of the ALC time constants. These circuits operate by deriving a linear approximation to the required delay compensation from control voltages V_A and V_B, as shown in figure 4-6.

Peak level detectors provide a means for comparing the actual peak ramp voltages against pre-established reference levels. The overall closed-loop operation is such that positive and negative peaks are independently regulated. Without the ALC, the VLS and main loop integrator delay totaling 25 ns would cause a 2-to-1 variation between 1 MHz and 10 MHz. With the ALC, amplitude variation due to delay becomes negligible, with second-order effects (such as peak detector inefficiency) becoming the limiting factors at the highest frequency.

In the following more detailed description, refer to the schematic diagram figure 7-3. The high-frequency ramp waveform, is peak-rectified via matched diodes A1-CR36 and A1-CR37. Operational amplifiers A1-IC9 and A1-IC11, connected as integrators, provide d-c gain. Selection between either the amplifier outputs or fixed d-c reference levels is made on the basis of frequency range. The complete ALC loop extends from the amplifier outputs to the VLS reference inputs, then to the main integrator, and back around to the peak detectors.

c. COMPENSATED LEVEL CONTROL. - The compensated level control amplifiers A1-IC10 and A1-IC14 are in series with ALC averaging amplifiers A1-IC9 and A1-IC11 respectively. in conjunction with resistive input networks, the amplifiers are adjustable for d-c control level and gain, thereby developing a first order correction for the loop delay. Note that, if this correction were perfect, there would be no need for the ALC circuits. However, because the correction is only approximate, the ALC supplies the necessary backup for maintaining accurate response in other than sweep or triggered modes. Interlocks through switches A1-S1, A1-S2, and A1-S3 provide for proper inspection of the level control circuits in accordance with selected modes and frequency ranges.

4-6. START/STOP AMPLIFIER

When in TRIG, GATE, or SWEEP BURST modes, the start/stop amplifier stops the operating of the main generator by inhibiting the

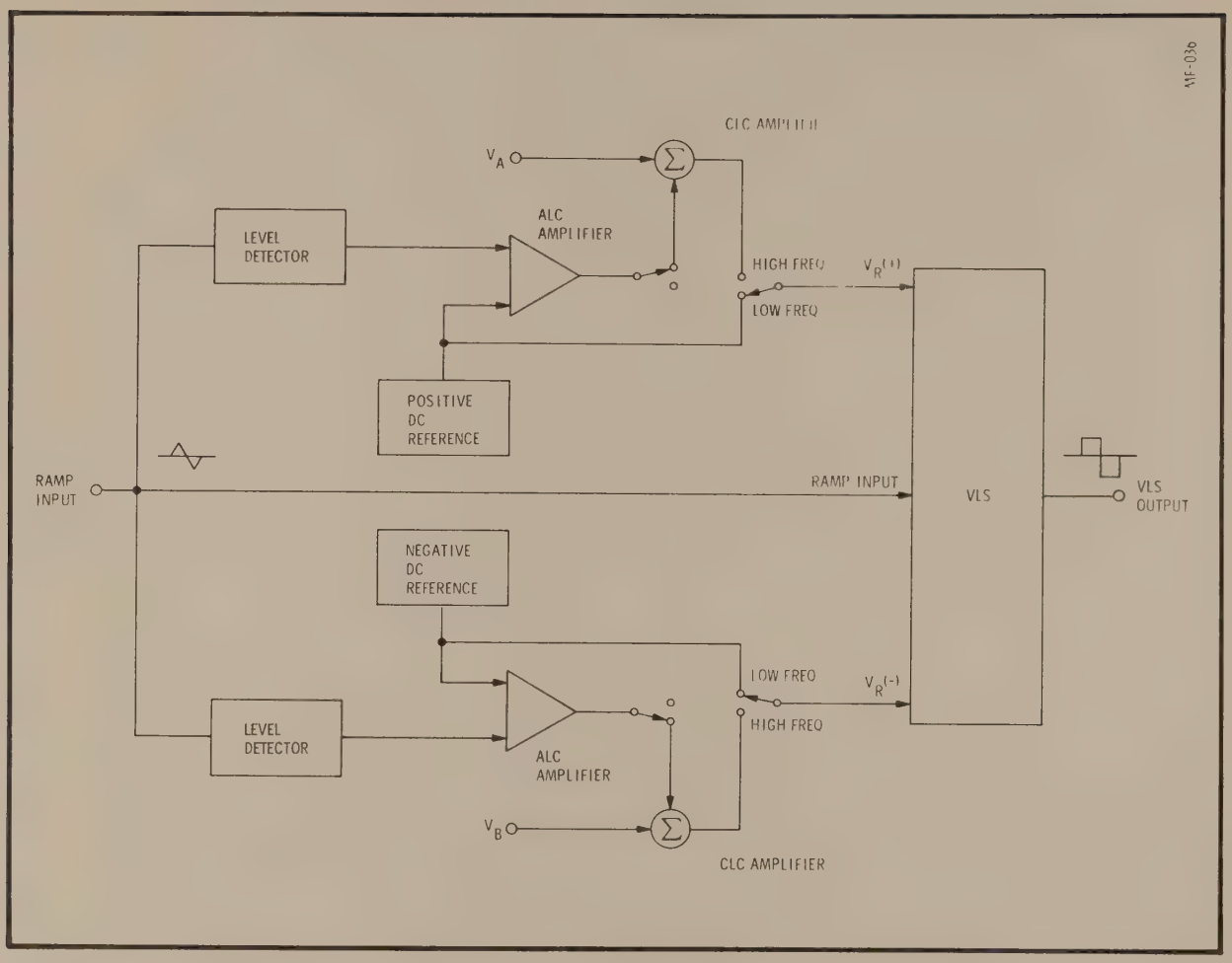


Figure 4-6. Automatic Level Control and Compensated Level Control, Block Diagram

triangle waveform. In these modes, the start/stop amplifier switches current from the integrating capacitor to the start/stop amplifier, thereby stopping generator oscillation.

The PHASE control determines the point at which the waveform is started and stopped. A1-R171 is a coarse adjustment trimmer for centering the PHASE control; if not properly adjusted A1-R171 can halt operation of the main generator.

Two logic inputs control start/stop amplifier operation; one from the voltage level sensor and one from trigger logic circuits (figure 7-3).

4-7. TRIGGER SYNC

The TRIGGER SYNC input circuit is simply a switch-controlled attenuator when used to synchronize the output. With reference to figure 4-7, the presence of a pulse on the trigger sync input line will cause an attenuation of the VLS reference voltage V_R (+) or V_R (-).

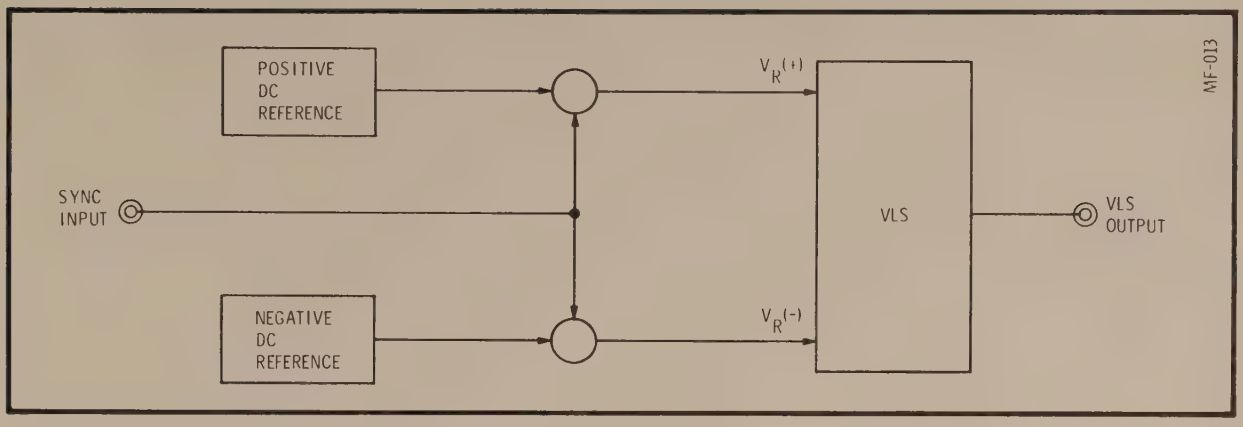


Figure 4-7. Sync Input, Block Diagram

If this pulse coincides within 0 to -1 percent to the peak of the integrator ramp waveform, a reversal of the ramp will be forced. The net result, over the limited range of 0 to -1 percent, is the ability to cause the function generator to synchronize to an external train of pulses.

Either transistor A1-Q49 or A1-Q50 is driven on by the presence of a synchronizing pulse of 1 volt or more. A positive synchronizing pulse must coincide within limits to the positive ramp peak, and similarly for the negative pulse and peak. The resultant attenuation of the reference level to the VLS will force synchronization of the ramp to the pulse.

4-8. SINE SHAPER

The sinusoidal signal that is available as one of the functions generated by the function generator is produced by applying the triangular waveform of the main loop to a nonlinear network having an input-output relationship as shown in figure 4-8.

The sine shaper block diagram is illustrated in figure 4-9. The triangular waveform driving the sine shaper has a peak-to-peak value of 6 volts.

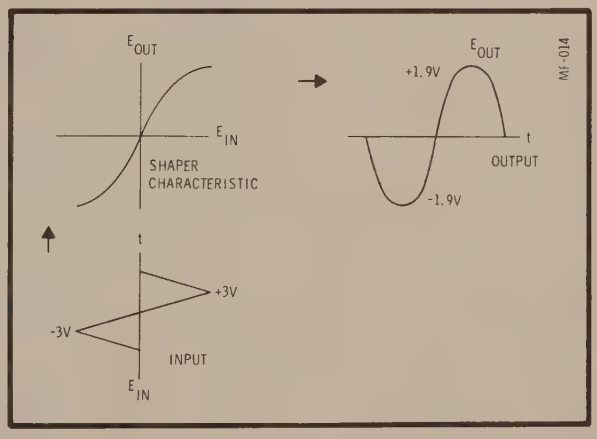


Figure 4-8. Sine Shaper Input/Output Diagram

Because of the sine-shaping process, the output peak value of the resulting sinewave will be approximately 3.8 volts peak-to-peak. In order to obtain a sinusoidal waveform of the same amplitude as the incoming triangular waveform, an amplifier is needed, with a gain of approximately 1.6.

The transfer characteristic shown in figure 4-8 is obtained by means of a network of resistors and voltage-controlled switches such that a nonlinear resistance is produced. The operation of this network is illustrated symbolically

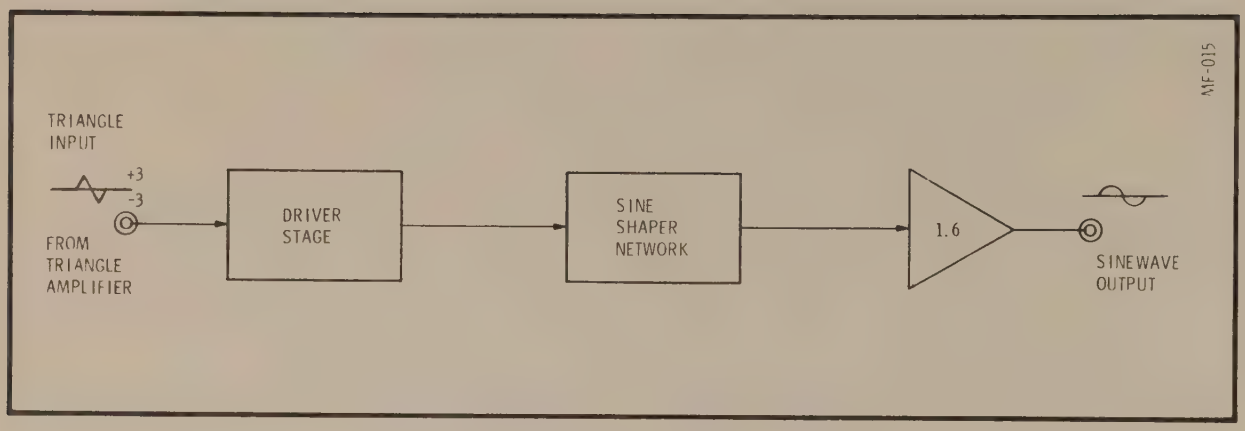


Figure 4-9. Sine Shaper, Block Diagram

in figure 4-10. The diode switches in the figure represent transistors in the actual circuits. Each switch will conduct whenever the voltage at the ladder network point to which it is connected reaches the bias level of the point to which it is returned.

Consider the triangular waveform shown at the driver input. At zero volts, all switches are open, and the signal appears unchanged at output A. As the voltage increases in the positive direction, a point is reached where the voltage at node 1 is e_1, and switch S_1 closes. This clamps node 1 to voltage $+e_1$ volts. As the input voltage continues to rise, the voltage at node 2 eventually turns on S_2, clamping node 2 to voltage $+e_2$. This continues until the input reaches +3 volts, each successive switch clamping its corresponding node to a higher voltage. The net result is that the series string of resistors A2-R132 through A2-R137 presents an increasing load to the signal through A2-R129, and the output waveform bends smoothly in a close simulation of a sinewave. The effect of switch S_7 is somewhat different. This switch closes just before the peak of the input triangle is reached, and its current passes through A2-R139 to ground. The voltage drop through A2-R139 generates the waveform shown at output point A. This is subtracted from the B signal by the differential amplifier, to remove the remaining discontinuity at the peaks of the B waveform.

In the downward travel of the input signal, this action reverses, and switches S_7 through S_1 are opened one at a time as the switch bias voltages are reached. The negative portion of the cycle is now handled by switches $S1_1$ through $S1_7$ in a similar manner.

The clamping switches used in the actual circuit are emitter followers, with their bases accurately biased by a precision resistive network. This provides a low-impedance path to ground for the signal currents, and minimizes fluctuations in the bias voltages that might be caused by the flow of the signal currents through the bias resistors. As a result, the lower impedance network provides improved high frequency characteristics.

In the following detailed analysis of the sine shaper refer to the schematic, figure 7-5.

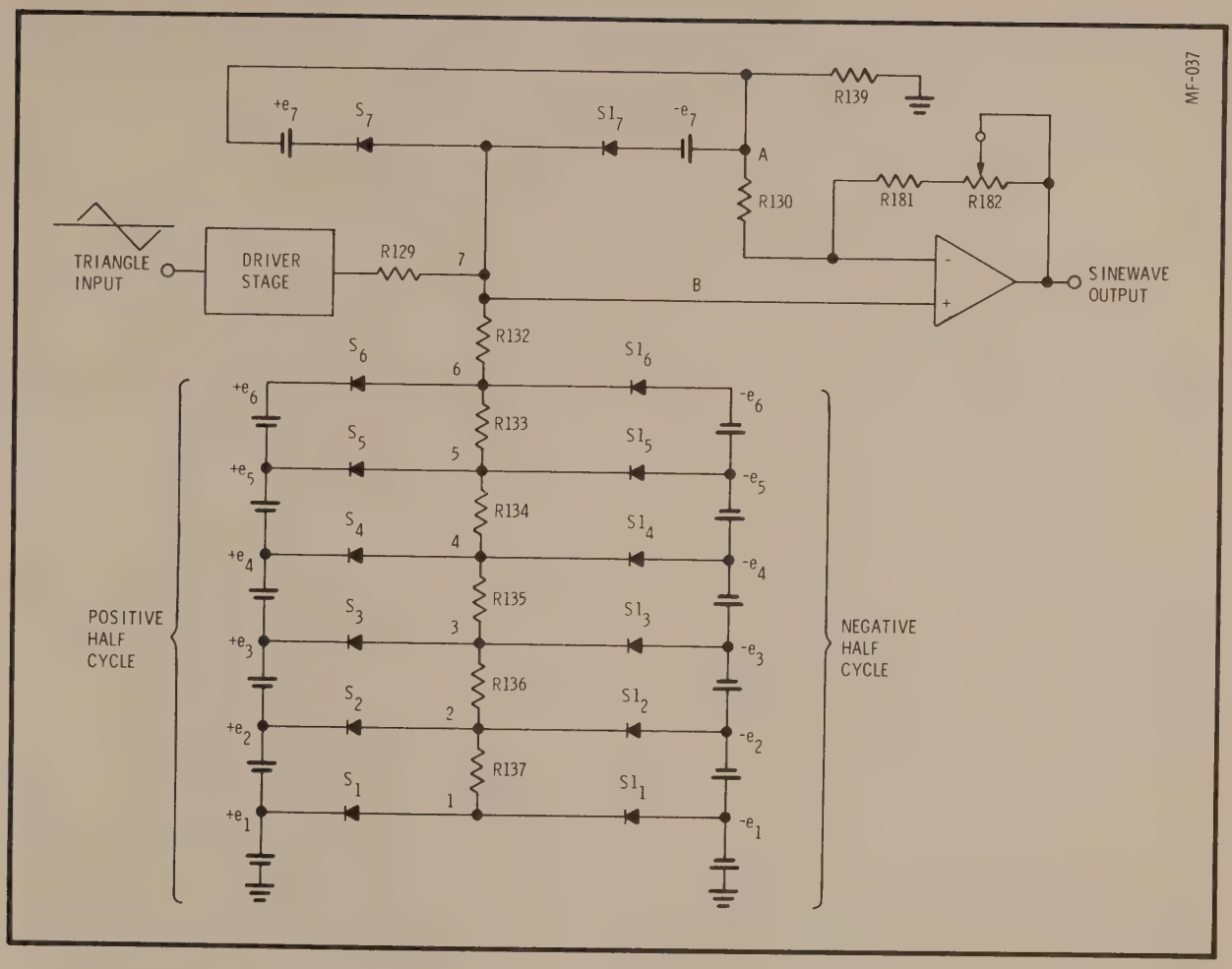


Figure 4-10. Sine Shaper Network

a. INPUT DRIVER. - This circuit comprises transistors A2-Q23, A2-Q24, A2-Q25, and A2-Q26. The dual complementary emitter-follower arrangement results in cancellation of base-emitter function biases, good thermal characteristics, and an output impedance or approximately 10 ohms. Note that because of the nonlinear load presented by the sine shaper to this driver, the waveform seen at A2-TP31 will not be linear, but will show signs of increased loading toward the peaks; its peak-to-peak voltage will be approximately 3.8 volts when the input triangle at A2-TP28 is 6 volts peak-to-peak.

b. SINE SHAPER. - This section involves transistors A2-Q27 through A2-Q44. Emitter follower A2-Q27 sets the positive voltage at the top of the resistive bias network A2-RN1. This voltage is adjusted by means of pot A2-R127. The foot of the ladder network is biased by means of emitter-follower A2-Q35. Both A2-Q27 and A2-Q35 are npn transistors, so that any temperature changes will cause

the top and foot of the ladder network to shift together in voltage. This provides temperature compensation to all clamp emitter-followers biased by the ladder.

Transistors A2-Q28 through A2-Q34 do the clamping for the positive half-cycle of the waveform. Each base is biased to a voltage 0.6 volt lower than the desired clamping level. Resistors A2-R132 through A2-R137 form the loading network for the driving resistor A2-R129

The circuitry on the right side (A2-Q36 to A2-Q42) is a mirror image of the section just described, and performs the same function for the negative half of the cycle. The partly-shaped waveform can be observed at A2-TP31. The peaks will still be pointed, however, because the peak cancellation transistors A2-Q28 and A2-Q36 operate on the waveform by means of the subtraction operation performed by the sine amplifier.

c. SINE AMPLIFIER. - The sine amplifier (comprising transistors A2-Q53 through A2-Q57) is of similar design to the triangle amplifier and inverter amplifier. The sine amplifier, like the triangle amplifier, is configured in the potentiometric mode. Overall gain with feedback is nominally +1.6. At the input to the amplifier, filter components A2-L3 and A2-C43 attenuate noise and distortion at frequencies above 10 MHz. The peak of the triangle waveform is cancelled by a signal across A2-R130, to the inverting input of the sine amplifier.

4-9. VARIABLE PULSE

The variable pulse circuits provide a means for obtaining an output pulse, variable between 5 percent and 95 percent duty cycle, at a repetition rate established by the frequency setting of the function generator. The variable pulse can also be modulated from an external ±10 volt source (PWM input).

Figure 4-11 shows the method of developing the variable width pulse. At some variable point during the ramp cycle, the sum of the instantaneous ramp voltage and the d-c output of the pulse width control will be zero. This point can occur anywhere within the extremes of the ramp. The output pulse will be a rectangular wave, with transistions at the two points on the ramp where the summed voltages are equal to zero.

As shown on the detailed schematic, figure 7-5, comparator A2-IC1 generates a positive-going pulse whenever the ramp voltage at A2-R27 is more positive than the variable d-c level at A2-R26. Feedback network A2-R30 and A2-R32 provides a small amount of positive feedback to ensure a clean transition. The comparator output is coupled to a current-mode driver (A2-Q10 and A2-Q11). The output of A2-Q11, clamped at ±5 volts, is buffered by a pair of complementary emitter follower drivers.

4-10. SUMMING AMPLIFIER AND OUTPUT AMPLIFIER

The output stages are designed in two sections. The first section is an inverting summing amplifier with multiple purposes:

- Introduces fixed offsets to obtain zero-based waveforms
- Attenuates signal 6 db in fixed offset modes
- Provides a low impedance drive to a calibrated attenuator.

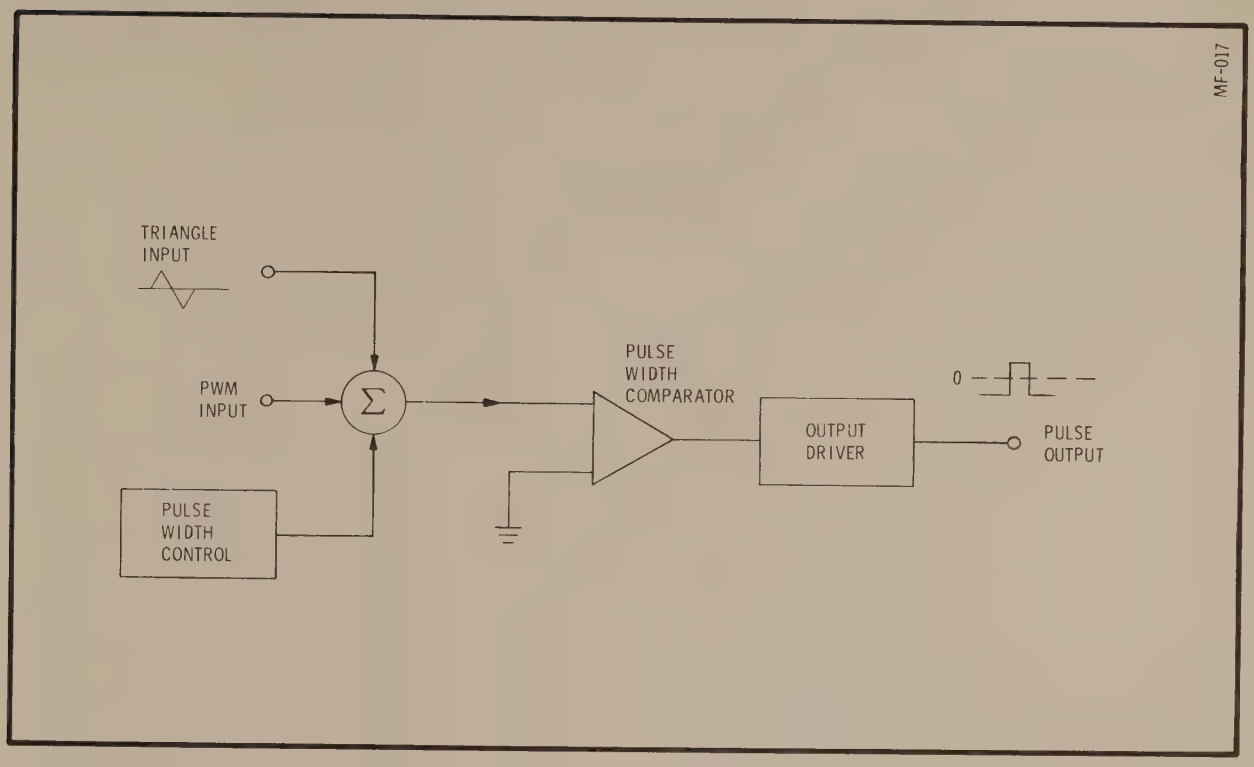


Figure 4-11. Variable Pulse Width, Block Diagram

The output section amplifies the signal from the attenuator to the voltage and power level needed for rated output. This amplifier operates as a (noninverting) potentiometric amplifier with inherently high input impedance. The attenuation is thereby unaffected by amplifier loading. The closed loop gain of the amplifier is nominally +5, which is adequate to ensure a 30-volt p-p output (open circuit) capability from internal signal sources.

Figures 4-12, 7-3, and 7-5 show the components of the output amplifier and its controls. Note that five front panel controls are associated with its operation; they are:

- WAVEFORM selector switch (A1-S2-4)
- OFFSET switch (A2-S1)
- OFFSET ADJUST control (A2-R4)
- OUTPUT ADJUST control (A2-R124)
- ATTENUATOR switch (A1-S3)

The output waveform, which may be one of several selectable by means of the WAVEFORM switch, can be amplitude controlled by either the step attenuator or the continuous OUTPUT ADJUST control. The step attenuator provides seven accurate attenuation steps from the maximum output signal of 30 volts peak-to-peak. With the OUTPUT ADJUST control set to the CAL position (fully clockwise), the output levels obtained by rotating the step attenuator will be as follows:

		50-Ohm Load
1st Position	No attenuation	15 volts p-p output
2nd Position	0 db Ref. level	10 volts p-p output
3rd Position	-10 db	3.16 volts p-p output
4th Position	-20 db	1.0 volt p-p output
5th Position	-30 db	0.316 volt p-p output
6th Position	-40 db	0.1 volt p-p output
7th Position	-50 db	0.0316 volt p-p output

For each of these positions of the step attenuator, the variable OUTPUT ADJUST control provides an additional 20 db of continuous attenuation.

The step attenuator is divided into two sections. The first, using a single switch pole, operates between the two amplifier stages and performs the attenuation for the -3 db from MAX to 0 db positions. The second section inserts 50-ohm pads at the output to provide the -10 db, -20 db, -30 db, -40 db, and -50 db overall attenuation steps.

The output stage gain can be adjusted by means of the variable resistor A1-R152 in its feedback path. The correct setting for this adjustment is such that the maximum output voltage into a 50-ohm load is 15 volts p-p, and corresponds very nearly to an amplifier gain of +5.

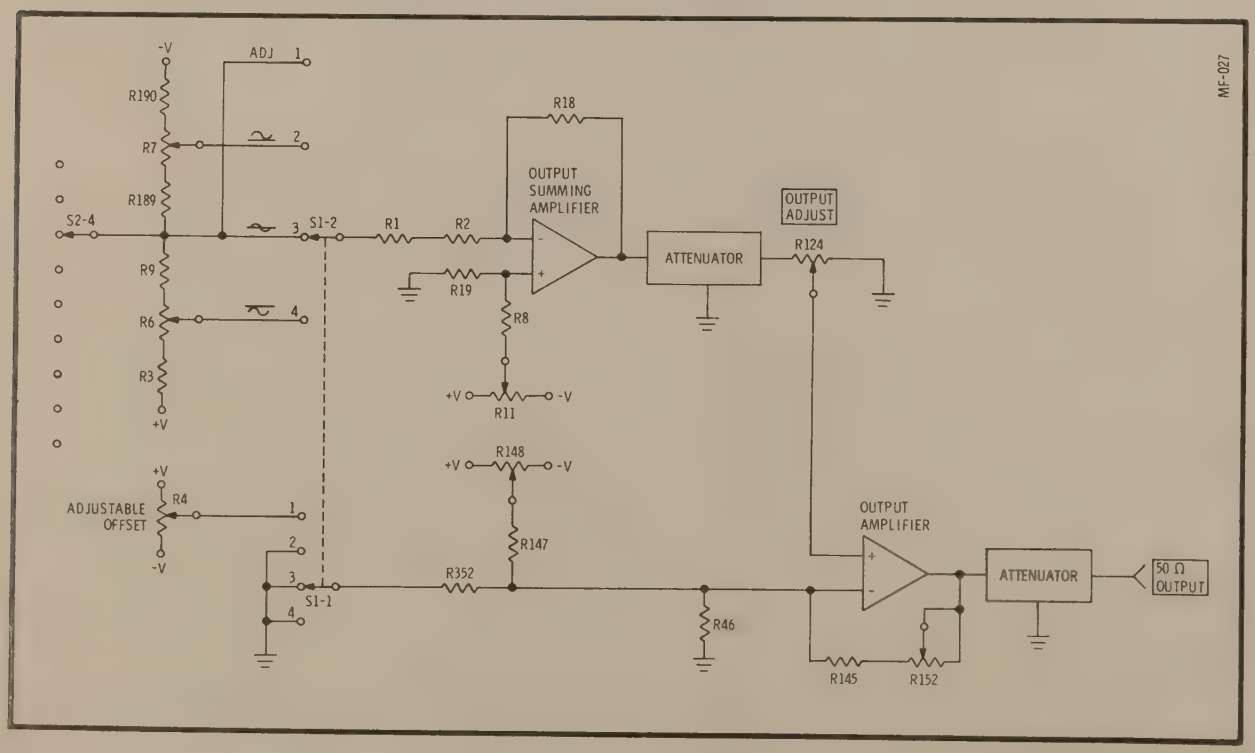


Figure 4-12. Output Amplifier, Block Diagram

The second section of the attenuator operates at the output terminal. It introduces no attenuation in positions 1 and 2 of the attenuator, because in these positions the signal reduction is provided by the interstage attenuator. In the next five positions of the switch, the second section progressively inserts a -10 db, a -20 db, and a -30 db pad in the output signal path, and then adds attenuator pads in series to obtain -40 and -50 db attenuation. Most of the attenuation is at the output terminal to ensure a good signal-to-noise performance ratio.

Attenuator Position	Interstage Section	Output Section
1st: 15 volts p-p	No attenuation	No attenuation
2nd: 0 db Ref. (10 volts p-p)	-3.52 db	No attenuation
3rd: -10 db	-3.52 db	-10 db
4th: -20 db	-3.52 db	-20 db
5th: -30 db	-3.52 db	-30 db
6th: -40 db	-3.52 db	-40 db
7th: -50 db	-3.52 db	-50 db

The interstage attenuator consists of a resistive divider comprising resistors A2-R122 and A2-R124.

The output amplifier signal is fed to the 50-ohm load through A1-R159 and A1-R160 (50 ohms) in the first two attenuator positions from 15 volts p-p to 0 db, the 10-volt reference. The resistive attenuator pads that are inserted in the next five positions are symmetrical 50-ohm pads. They are so designed as to minimize the resistor values used in order to reduce the effects of stray capacitance on the waveform. The first is a -10 db π section (A1-R159 through A1-R163). The second is a -20 db T section (A1-R345, A1-R346, A1-R347). The third is a -30 db pad using four components (A1-R348 through A1-R351). The fourth and fifth are seried attenuator pads.

In the following detailed description, refer to figure 4-12 and schematic figure 7-5.

a. WAVEFORM AND OFFSET SWITCHES.- The input signal that drives the summing amplifier is derived from the wiper arm of the WAVEFORM switch (A1-S2-4), where one of nine possible waveforms may be selected. Each of these waveforms comes from a source whose equivalent circuit consists of a 6-volt p-p generator with an internal impedance of 100 ohms. The signal is fed to the summing amplifier input resistor (A2-R1). Additional inputs to the summing amplifier are derived from the OFFSET switch (A1-S3), providing for fixed modes. The fixed offset level is resistor-summed with the input signal which also attenuates the signal by 6 db. The adjustable offset is introduced into the final output amplifier at the inverting input by switching in a variable d-c level by A2-R4.

b. SUMMING AMPLIFIER. - The summing amplifier is configured as an inverting amplifier with an overall gain of -1. Differential pair A2-Q1 and A2-Q2 is a common emitter pair, with the overall amplifier summing junction at the base of A2-Q1. Common base amplifier A2-Q5 provides voltage gain, and high frequency amplifier A2-Q6 assists in obtaining wideband response. Output emitter followers A2-Q7 and A2-Q8 provide the necessary low impedance for driving the attenuator network and OUTPUT ADJUST control.

c. OUTPUT AMPLIFIER. - The signal from the OUTPUT ADJUST control is fed directly to input transistor A1-Q18. Differential pair A1-Q19 and A1-Q20 is a common emitter pair amplifier, with overall amplifier feedback applied to base of A1-Q42. Transistors A1-Q44 and A1-Q18 serve as current sources to bias the common base output drivers A1-Q21 and A1-Q22. Current sources A1-Q44 and A1-Q18 are also driven at high frequencies through A1-C45 and A1-C44, thereby extending high frequency performance by an order of magnitude. Cascaded emitter followers A1-Q23 through A1-Q26 provide necessary power gain to supply the amplifier load.

4-11. TRIGGER LOGIC CONTROL

Operational modes, involving the use of an external trigger, utilize the differential comparator A2-IC2. The input signal is summed with a d-c potential derived from the TRIGGER LEVEL control. This control allows a point of an input waveform to be used as a trigger level. The output of the comparator is buffered and inverted by A2-IC3A and A2-IC3B. The TRIG SLOPE pushbutton selects either a positive or a negative slope to be used as a trigger. The MAN pushbutton allows internal trigger operation without need of an external trigger connection.

When the MAN pushbutton is depressed, A2-IC3C and A2-IC3B form a lock-up circuit which prevents multiple triggering that may occur from switch contact bounce.

A2-IC3 through A2-IC7 are NAND gates which have the logic characteristics shown in the truth table, figure 4-13. Refer to the control logic timing diagrams in figure 5-11 and to the schematic diagram, figure 7-5, for the following description.

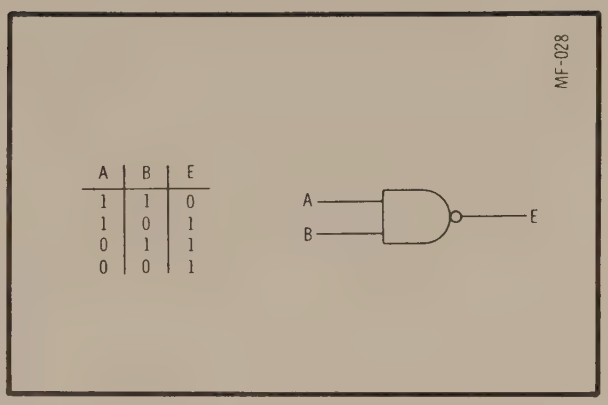


Figure 4-13. NAND Logic

a. TRIGGER MODE. - In TRIG MODE an external trigger or manual pushbutton forces A2-TP7 high and A2-TP8 low. When A2-TP8 goes low, A2-TP9 follows low and the d-c logic signal to the start/stop amplifier goes low, unlocking the waveform generating loop and allowing the waveform generator to begin. The start/stop amplifier may be released for operation by either the logic signal just described going low, or by a squarewave logic signal derived directly from the VLS going low, or both. In standby, the VLS logic signal is stalled high so the waveform commences as a result of A2-TP9 going low.

As A2-TP9 goes low, A2-IC4B pin 6 is forced low; A2-TP6 goes low; IC4A pin 2 goes low and A2-TP8 goes high. Thus, regardless of how long external trigger A2-TP7 remains high, A2-TP8 is reset as soon as A2-TP9 is latched. Another trigger cycle cannot occur until A2-TP7 is allowed to go low, resetting A2-TP6 high and re-establishing the initial conditions.

Conditions required for removing the operate command A2-TP9 from the waveform generator are:

(1) VLS waveform must be positive at A2-IC4D pin 13.

(2) A2-TP8 must be positive (indicating trigger reset).

(3) A2-IC5B pin 7 must be positive (indicating a logic GO command).

When these three conditions are present, A2-IC4D pin 14 goes low, setting flip-flop output A2-TP10 low.

At this time, A2-IC5C pin 9 (the logic run flip-flop reset line) is high because the VLS waveform is high. When the VLS waveform goes low (because of the main loop oscillator waveform reversing slope), A2-IC5C pin 9 will go low and reset A2-TP9 to initial conditions. The start/stop amplifier still commands waveform generation; however, because the VLS waveform also enters a start/stop amplifier, it holds the run command until the VLS waveform again goes positive.

b. GATE MODE. - The GATE MODE operates exactly as described for trigger mode except that the line A2-IC4A pin 2 is held high at all times. This holds A2-TP8 low for the entire time that a trigger signal A2-TP7 is present (high). When A2-TP7 goes low the generator completes its cycle and stops.

c. CONTINUOUS MODE. - In CONT MODE, the start/stop amplifier is forced into a run mode by grounding the logic line at the CONT MODE switch.

A2-IC4A pin 2 is similarly grounded and prevents A2-TP8 from being operated by any external conditions.

The external TRIGGER SYNC input is rerouted to the main loop sync circuit allowing external signals to force waveform transitions and thus provide a range of waveform sync lock.

d. PHASE-LOCK MODE.‡ - In ϕ LOCK mode, an external trigger forces A2-TP9 low, (as in normal trigger mode), and an internal trigger, derived from VLS waveform, forces A2-TP9 to reset high. The reset requirement is slightly different than trigger mode operation in that, once reset, the reset signal A2-IC5 pin 9 must disappear quickly to allow acceptance of another trigger. A2-IC6 has been added to provide the same capability for the VLS waveform that A2-IC7B and C provides for the trigger signal.‡

IC5 pin 7 is set low in a trigger mode operation: A2-TP7 goes high and A2-TP8 goes low; A2-TP9 goes low, and A2-TP2 resets high.‡

With A2-TP9 low, A2-IC5 pin 7 and A2-IC6 pin 6 are high. Flip-flop A2-TP12 is forced high by the VLS waveform (free running) being high (A2-IC6 pin 13); (A2-TP11) is low.‡

When the VLS waveform goes low, A2-TP11 goes high and gate output A2-TP14 goes low, resetting A2-TP9 high and A2-IC5 pin 7 low. A2-IC5B pin 7 going low, resets A2-TP12 high and forces A2-TP14 high, thus completing the reset cycle of A2-TP9 and clearing the flip-flop A2-IC5B and C for a new trigger.‡

Flip-flop A2-IC5B and A2-IC5C thus form a digital phase detector with transitions in one direction forced by the external input trigger, and transitions in the other direction forced by the waveform generator. If these transitions are equally spaced, a timed symmetrical

‡ The Model F54 does not provide the phase-lock feature.

wave will be produced which indicates a fundamental phase lock at 180 degrees. As the symmetry varies, indications up to ±180 degrees from this point may be observed. This is detected by d-c averaging the waveform in the phase-lock circuitry.‡

An additional A2-IC7 has been added to indicate (by means of a lamp) when the waveform generator is phase locked at the same frequency as an external trigger frequency. This is explained in a logical order as follows:‡

(1) The positive edge of an incoming trigger causes A2-IC5 pin 7 to go high. Because A2-TP7 is differentiated, the pulse so produced disappears before A2-IC5B pin 7 goes high and no negative edge will be produced at A2-TP16. If however, an A2-TP7 pulse occurs while A-IC5B pin 7 is already high, a sharp negative-going pulse will occur at A2-TP16. This indicates either a plurality of pulses on the A2-TP7 line, or that the input trigger frequency is above the waveform generator frequency.‡

(2) A similar action in gate A2-IC7B indicates, by negative-going pulses, when the input trigger frequency is below the waveform generator frequency.‡

(3) A negative pulse on either gate A2-TP15 or gate A2-TP16 initiates a one-shot circuit. A2-IC7 pin 3 is forced low by the spike; the lamp transistor A2-Q14 is released; the lamp goes out, and timing capacitor A2-C20 begins to charge in a positive direction. When a sufficiently positive potential is achieved, unijunction transistor A2-Q15 fires and transistor A2-Q16 conducts, causing A2-IC 7 pin 3 to go high A2-Q14 conducts, and capacitor A2-C14 is discharged through A2-Q14 and A2-Q15. When another negative pulse is received, the process is repeated.‡

e. SWEEP CONTINUOUS MODE. - In SWEEP CONT mode, both the main generator and sweep generator are in a continuous (free running) mode. The sweep ramp waveform is applied (after attenuation by the SWEEP width control) to the VCG INPUT of the main generator.

f. SWEEP BURST MODE. - In BURST MODE the main generator operates in the GATE mode, while the sweep generator is free running. The sweep waveform is not connected to the VCG INPUT; therefore, it does not alter the frequency of the main generator. The sweep waveform is connected to the external trigger input of the logic and is used in place of an external trigger. Depending upon the setting of the TRIG SLOPE and TRIGGER LEVEL control, a gate of variable width causes the main generator to start and stop.

g. SHIFT MODE. - In the SHIFT (sweep and hold) MODE, the main generator is free running. An external trigger signal sets A2-TP9 low and causes the sweep generator to begin a cycle. A sweeping signal from the sweep generator resets A2-TP8 after the sweep is in motion. The sweep ramp is connected to the VCG INPUT and the main generator increases in frequency until the peak of the sweep ramp is reached. At this time, logic in the sweep generator holds the sweep waveform at its peak level and the main generator holds a representative high frequency. When sweep circuitry is manually reset, the process may be repeated.

h. SWEEP TRIGGER MODE. - Upon receiving an external trigger signal in SWEEP TRIG

‡The Model F54 does not provide the phase-lock feature

MODE. A2-TP8 goes low, setting A2-TP9 low. This removes the lock-up on the main generator and waveform generation begins. At the same time, A2-TP9 sends a logic signal to the sweep section causing sweep waveform generation to begin. As soon as the sweep is in motion, a sweeping logic signal is received resetting A2-TP8 high. The sweeping signal also prevents lock-up at the end of a waveform cycle by inhibiting the action of gate A2-IC4 pin 12. When a sweep cycle has been completed, the VLS waveform is allowed to pass through gate A2-IC4 pin 14, stopping the main generator upon completion of the waveform.

4-12. PHASE-LOCK CONTROL ‡

The function generator can be phase-locked to an external signal injected at the TRIGGER SYNC terminal, with the ϕ LOCK pushbutton depressed. Under these conditions, the function generator output signal frequency will be identical to the input signal frequency, and will track this signal over a range equal to that of the frequency dial setting. Further, it can be made to track any harmonic (up to a least the fifth) of the input signal, or any subharmonic (down to at least the fifth). The input signal may be a sine, triangle, or squarewave, or a train of pulses. The phase, or time, relationship between output and input can be continuously adjusted to nearly one-half a period of the highest frequency signal. This amounts to ±180 degrees when the fundamental is being tracked.‡

The block diagram of figure 4-14 shows the basic elements of the loop. Note that the block labeled VOLTAGE CONTROLLED GENERATOR (VCG) represents the main waveform generating circuitry. This circuitry comprises the current control circuits, triangle generator, and level sensors. The circuitry generates the function generator waveform that is to be phase-locked to the input signal, and whose frequency can be changed by means of a control voltage applied to its input.‡

The input signal is first passed through a comparator stage where it is voltage-limited to provide an accurate determination of the zero-crossing points of the input waveform. Switch A2-S3-3 (TRIG SLOPE pushbutton on front panel) permits the operator to select a signal either in phase with the input or 180 degrees out of phase with the input, for use at the digital phase detector.‡

These, then, are preliminary wave-shaping functions, and are not directly related to the actual loop operation.‡

The digital phase detector is a set/reset flip-flop which is set by the input waveform at S and reset by the VCG signal at R as shown in the block diagram, figure 4-14. Assuming that these two signals are of equal frequency and 180 degrees apart, the resulting waveform at the phase detector output will be a squarewave (50 percent duty cycle). The duty cycle of the output waveform will deviate from 50 percent if the phase angle between the S and R input signals deviates from 180 degrees, as shown in figure 4-15.‡

The positive-going edges of the S and R signals are shown in heavy lines (figure 4-15) to illustrate the fact that it is these transitions which trigger the flip-flop into a change of state. Because the negative-going transitions have no effect, the duty cycle of the input

‡ The Model F54 does not provide the phase-lock feature.

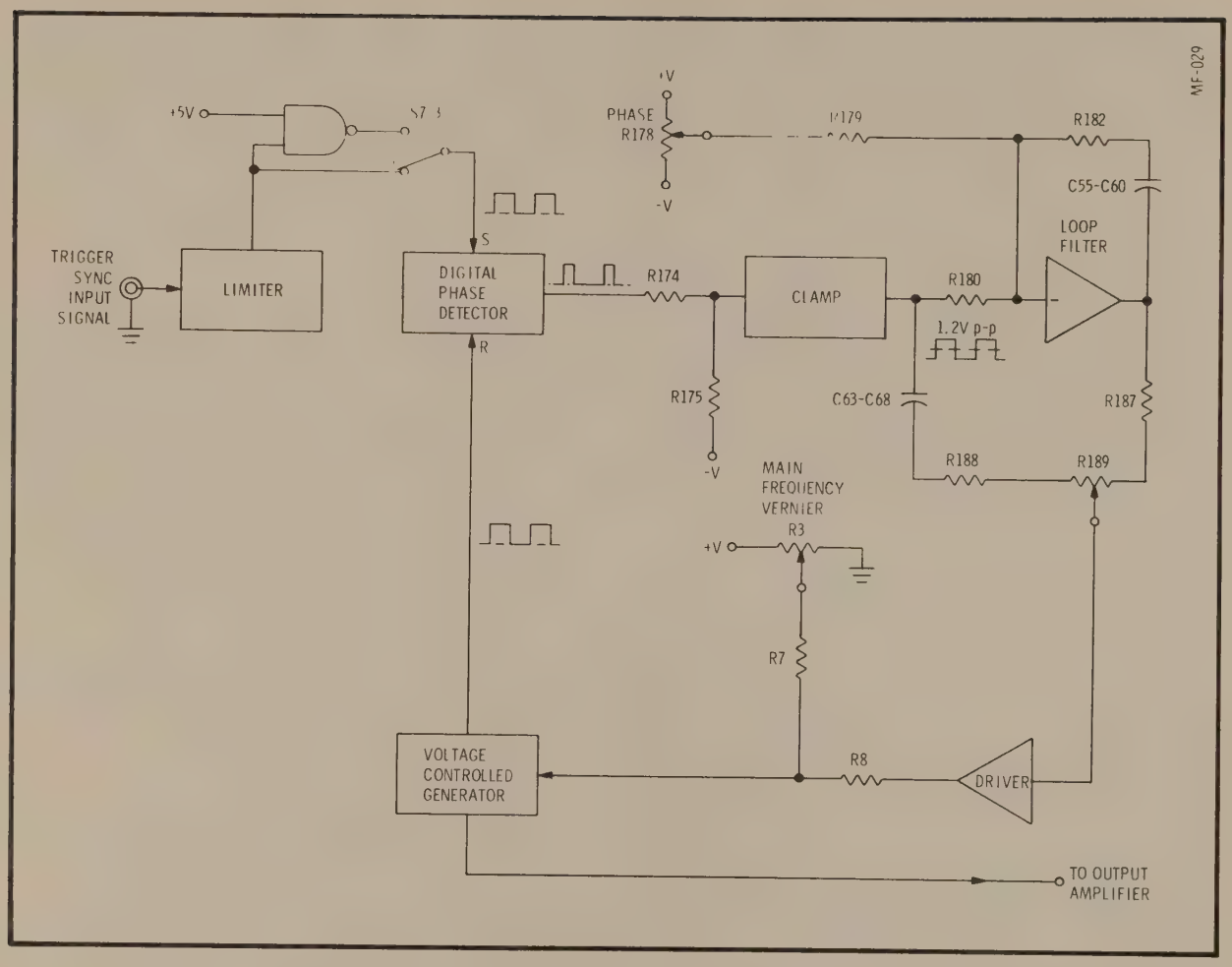


Figure 4-14. Phase-Lock Loop, Block Diagram

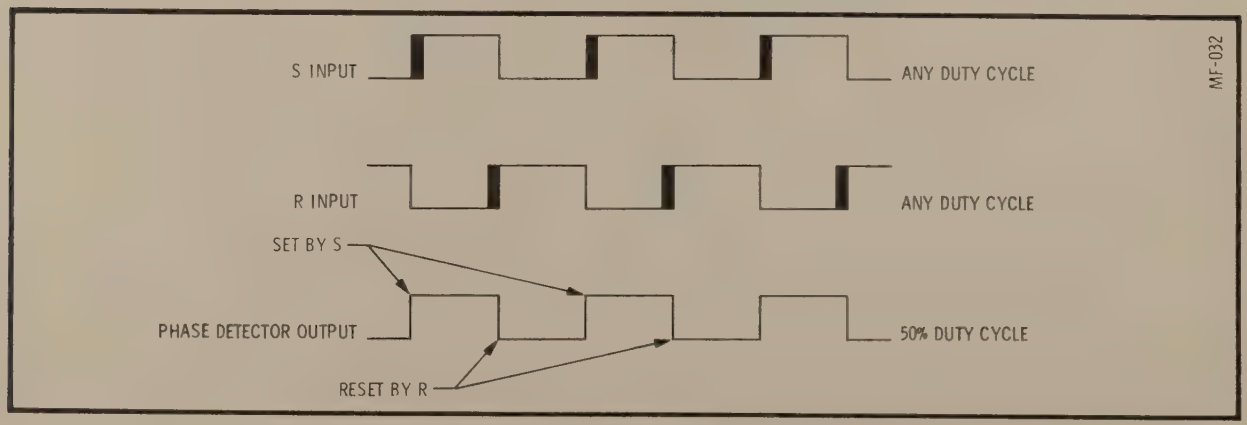


Figure 4-15. Phase Detector Waveforms for $\phi = 180°$

signals is irrelevant, and the phase angle between the S and R signals is defined strictly in terms of the positive-going edges. If the phase angle is less than 180 degrees, the duty cycle at the output will be less than 50 percent. Figure 4-16 shows these waveforms.‡

Thus, a net d-c voltage change will appear at the output which is a linear function of the phase angle of the input signals over a range of ±180 degrees.‡

Integrated circuit TTL devices are used in the digital phase detector and, as a result, the output waveform swings between zero and approximately +2.4 volts. A negative voltage is added to this signal and the result is applied to a diode clamp to obtain a signal which is symmetrical about zero. In this way, a signal of ±0.6 volt is obtained, and its net d-c voltage is zero when the duty cycle is 50 percent (corresponding to 180 degree input phase angle). Integration of this signal by an active integrator produces the d-c voltage which is used to control the VCG signal frequency that closes the loop at the R input of the phase detector.‡

The integrator, as shown in figure 4-14, is shunted by the network composed of A1-C63 through A1-C68 and A1-R188 in series, so that two signals are added at the arm of potentiometer A1-R189. The signal at the output of the integrator contains the d-c voltage obtained by integration over the past history of the input signal, and also some a-c signal equal to the input signal times the ratio A1-R182:A1-R180. A1-R182 cannot be made equal to zero because the loop would then be completely undamped, and in this case, unstable. But, by adding the a-c component of the input signal in phase opposition with the output, and using the proper time constant in the cancellation path, this ripple signal can be almost completely eliminated. If this cancellation is not effected, the output ripple will modulate the VCG in such a way that its output signal duty cycle will not be 50 percent when the loop is closed.‡

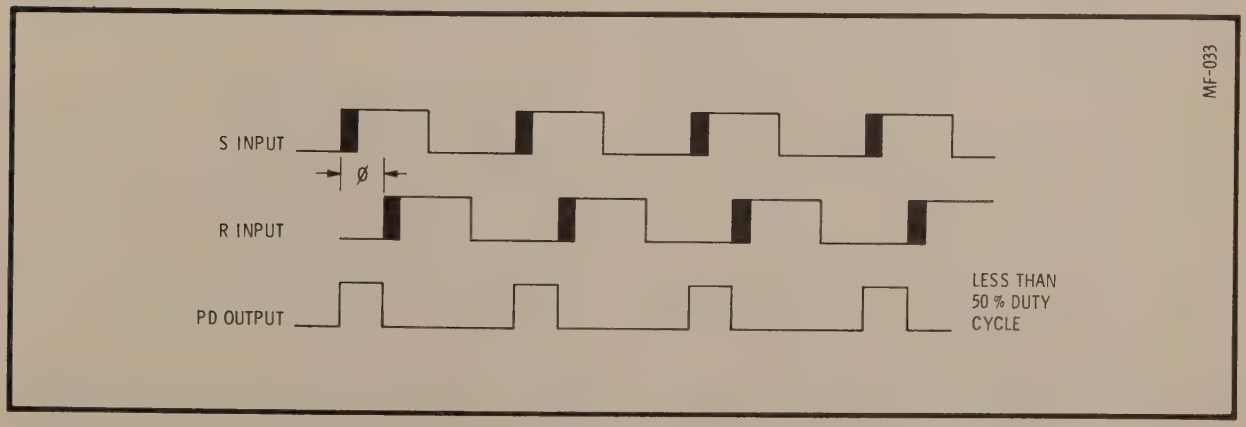


Figure 4-16. Phase Detector Output for $\phi < 180°$

‡The Model F54 does not provide the phase-lock feature.

The capacitors in the active integrator circuit are connected to the MULTIPLIER switch, so that their values change in sync with frequency range changes at the MULTIPLIER switch.‡

In the ϕ LOCK mode, fundamental frequencies can be tracked from 10 Hz to 10 MHz. Harmonics and subharmonics can be tracked provided that the output frequency remains within the 10 Hz to 10 MHz limit.‡

The PHASE control shown in figure 4-14 performs two functions: when the fundamental is being tracked (that is, the voltage controlled generator signal frequency is the same as that of the input signal), this control varies the phase angle of the two signals by adding a d-c current through A1-R179 to the amplifier input terminal. This current forces the loop to stabilize at some phase angle that will cause the detector output to cancel the input current. The PHASE control is used to phase-lock a harmonic (or subharmonic) of the input frequency. The conditions for tracking the third harmonic of a signal are shown in figure 4-17. The phase detector output voltage has a net negative value. If a positive d-c voltage is added to the input signal via the PHASE control, the loop will be phase-locked to the input, but the function generator output signal will have a frequency of exactly three times the input frequency.‡

The description that follows covers the loop filter and its accessory circuits, as shown in the schematic diagram, figure 7-3.‡

The output waveform of the digital phase detector, swinging between zero and +2.4 volts, is first passed through a clamping circuit comprising transistor A1-Q31 and diodes A1-CR24 and A1-CR25. Resistors A1-R174 and A1-R175 offset the signal negatively using the -5 volt supply, and emitter follower A1-Q31 drives the clamping diodes through A1-R177. At diodes A1-TP34, the waveform is limited to ±0.6 volt peak swing. Changes in the input duty cycle (caused by phase errors at the phase detector input) appear at this point as a d-c level that can vary between the limits of the + and -0.6 volt. This d-c level is applied through A1-R180 to the inverting input of high gain amplifier A1-IC6. Depending on the range being used, the switch places one of six capacitors in the feedback path in series with damping resistor A1-R182. The noninverting input of the amplifier is returned to ground via A1-R183. Capacitors A1-C61 and A1-C62 and resistor A1-R186 are stabilizing components required by A1-IC6. At the output of amplifier A1-TP35, a voltage will exist which is the integral of the d-c phase level obtained at the diode clamp. Because of the presence of A1-R182 in the feedback path, this integral will have added to it a ripple caused by the a-c signal of the clamped waveform.‡

In order to reduce this ripple to a minimum, a cancellation network is used, with potentiometer A1-R189 as a summing point. Emitter follower A1-Q32 applies the clamped waveform to a capacitor, also selected by the MULTIPLIER switch, and through A1-R188 to one end of A1-R189. The output of the integrating amplifier, through A1-R187, appears at the other end of A1-R189. As the a-c signals appear at the summing point in phase opposition, they cancel out and do not appear at the base of output emitter follower A1-Q33. The d-c

‡ The Model F54 does not provide the phase-lock feature.

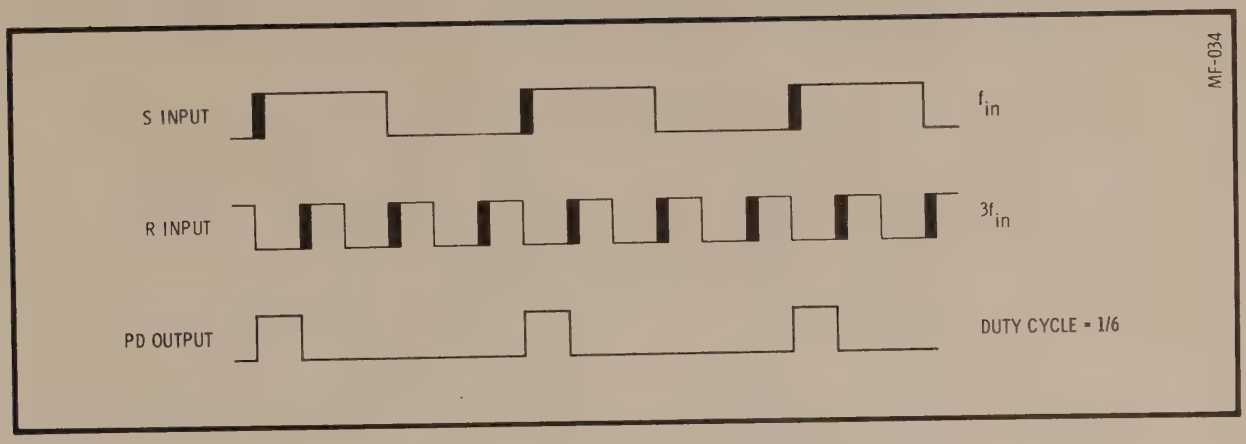


Figure 4-17. Third Harmonic Tracking

level of the integrator output is not cancelled, and is used to drive A1-Q33, whose emitter output voltage is routed to the voltage controlled generator summing point. Transistor A1-Q34 works as a current source for A1-Q33.

4-13. SWEEP GENERATOR

The sweep circuitry generates a saw-tooth waveform as shown in figure 4-18. An operational integrator and a voltage comparator make up the basic oscillating loop. Digital gates control the sweep generator for the various triggering modes.

a. BLOCK DIAGRAM DESCRIPTION. - A logic signal controls the voltage comparator which enables or inhibits the sweep generator. Current charges the integrator feedback capacitor and produces a linear ramp waveform. When the ramp voltage reaches the threshold level of the comparator, an FET transistor shorts out the integrator capacitor, thereby producing a saw-tooth wave with a recovery time of approximately 1 percent.

The output of the comparator is buffered by a driver stage and utilized as the SWEEP SYNC output signal (figure 4-19).

The sweep output amplifier provides the power to drive four output loads and contains the gain, baseline, and hold adjustments. The digital circuitry consists of eight NAND gates which control comparator operation during SWEEP TRIG mode, and the hold signal during the SWEEP SHIFT mode.

There are four basic trigger mode pushbuttons and two calibration pushbuttons in SWEEP mode. They are:

- CONT (repetitive sweep)
- TRIG (single sweep cycle)
- SHIFT (sweep and hold)
- BURST (repetitive sweep trigger)
- RESET (minimum sweep level)
- CAL (maximum sweep level)

b. DETAILED SCHEMATIC DESCRIPTION. A1-IC7 is an operational amplifier with an

‡The Model F54 does not provide the phase-lock feature.

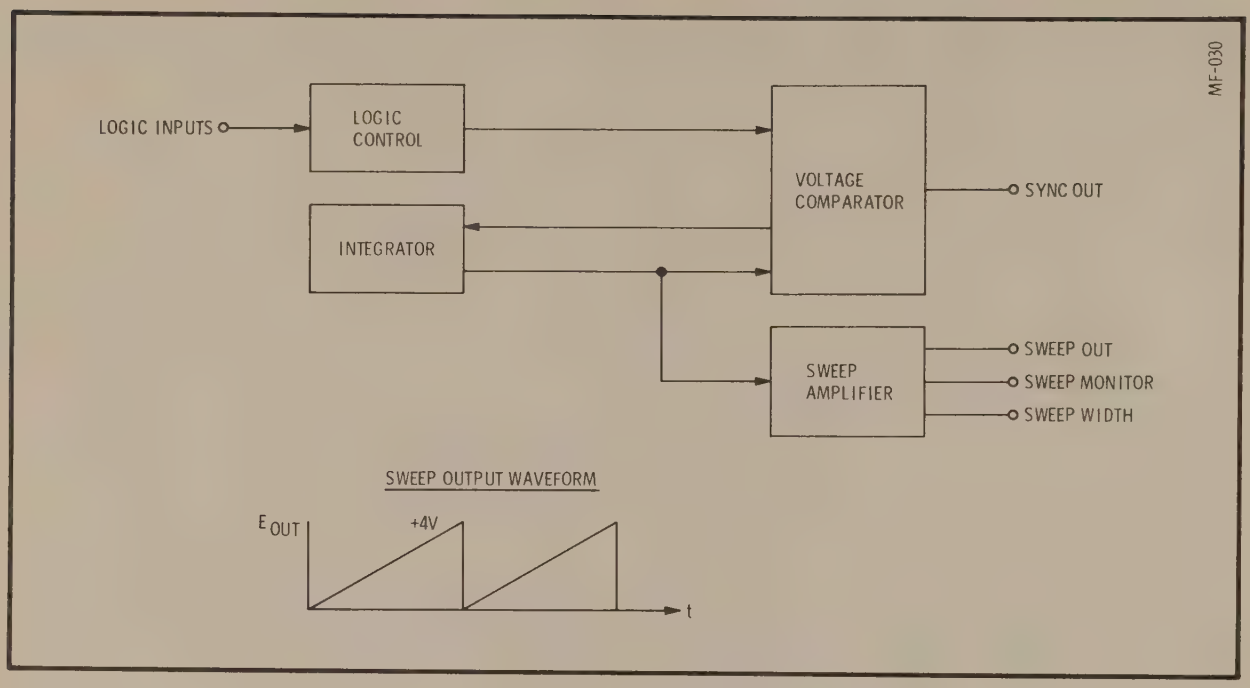


Figure 4-18. Sweep, Block Diagram

FET front end to minimize bias currents (figure 7-3). Because it is utilized as an operational integrator, current flows through the input resistor (A1-R196 to A1-R210) and charges the integrator capacitor (A1-C70 to A1-C72). This produces a linear voltage ramp at A1-TP28. A1-IC8 is a voltage comparator which triggers when the voltage ramp reaches -4 volts. A1-CR66 level shifts the output of A1-IC8 so that A1-Q37 and A1-Q38 can swing the output voltage at A1-TP29 from about +10 to -20 volts. The transistors A1-Q37 through A1-Q40 act as switches to produce a narrow SWEEP SYNC pulse output. The low frequency offset adjustment (A1-R207) minimizes the drift rate error of the operational integrator. The threshold level and stability of comparator A1-IC8 is controlled by A1-R223. The comparator uses positive feedback and a 4-volt hysteresis loop to determine its threshold level. A1-R220 through A1-R223 set the hysteresis level.

When the comparator triggers at A1-TP29, it causes FET switch A1-Q35 to short out and discharge all the current in integrating capacitor A1-C70 to A1-C72. This returns the voltage at A1-TP28 to zero. The comparator then has a new threshold level (almost zero volts). When the voltage at A1-TP28 reaches zero, it again triggers the comparator and opens FET switch A1-Q35, thus allowing the cycle to repeat itself.

Eight logic gates control the comparator and triggering modes of the sweep output. A2-TP19 and A2-TP21 are the only logic inputs to the sweep circuitry. A2-TP19 must be in the low

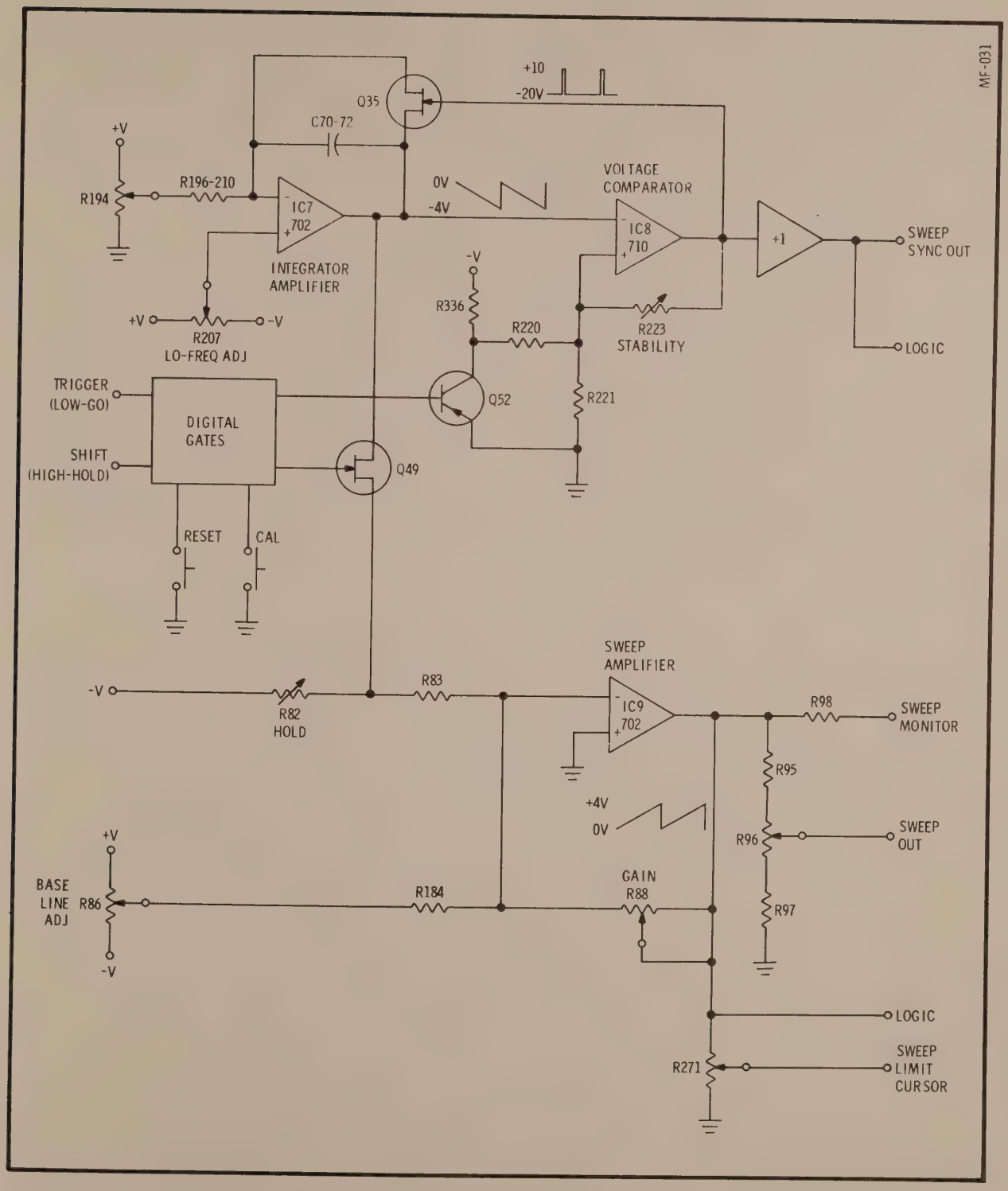


Figure 4-19. Detailed Sweep, Block Diagram

state for the sweep generator to operate. Pressing the RESET pushbutton also stops the sweep operation by bypassing the logic gates and placing A2-TP24 in the low state. In the SHIFT mode (sweep and hold), A2-TP21 is in the high state and, after one sweep cycle, will keep the sweep at about +4 volts at A2-TP26. This level is adjusted by A2-R82. The RESET pushbutton must be pressed to unlatch the logic circuitry from this holding mode before another sweep cycle can be initiated.

A2-Q49 is a series FET switch which disconnects the operational integrator from the sweep amplifier, thereby allowing the hold signal via A2-R82 to hold the sweep output voltage at about +4 volts. Transistor switches A2-Q45, A2-Q47, A2-Q48, and A2-IC10 allow the high state at A2-TP21 to control switch A2-Q49.

The sweep amplifier A2-IC8 acts as an inverting unity gain amplifier supported by A2-Q50 and A2-Q51 to handle the power required to drive the load. The feedback path is through A2-R87 and A2-R88 where A2-R88 can vary the gain. The baseline of the sweep waveform is adjusted by summing in a d-c voltage level to the amplifier via A2-R86. When the amplifier is not in the hold mode, A2-Q49 is a short to the signal path, swamping out the input signal from A2-R81 and A2-R82. However, in the hold mode, A2-Q49 is open and A2-R82 adjusts the input signal so that the sweep output at A2-TP26 remains at about +4 volts.

There are two pushbuttons which circumvent the sweep logic and allow minimum sweep (zero baseline) and maximum sweep (+4 volts) to be observed. The RESET pushbutton forces +1 volt on A1-TP30 and stops the comparator from operating; it also removes the baseline offset voltage from the sweep amplifier, thereby producing a zero volt signal at A1-TP28 and A2-TP26. The CAL pushbutton turns on A2-Q48 and turns off A2-Q49 allowing the hold signal from A2-R82 to hold the output voltage at A2-TP26 at about +4 volts.

4-14. POWER SUPPLY

Six regulated d-c power sources are required for the waveform generator circuits; these are ±5 volts, ±12 volts, and ±24 volts. These supplies are referenced to a single zener reference diode such that each voltage varies proportionally with the reference.

The power supply (figure 7-7) consists of six fullwave rectifiers for use with the ±5 volt, ±12 volt, and ±24 volt regulators.

The raw dc is furnished by transformer A3-T1, rectifier diodes A3-CR1 through A3-CR4, A3-CR11 through A3-CR14, A3-CR27 through A3-CR30, and filter capacitors A3-C1, A3-C6, A3-C17, A3-C22, and A3-C27. When power is first applied, no +12 volts appears at A3-TP3 because amplifier A3-IC3, reference diode A3-CR20, and control transistor A3-Q7 have no power. Raw +5 volt and -5 volt power is furnished to A3-IC3 and A3-IC4 through diodes A3-CR23 and A3-CR22. Raw +12 volt power is supplied to A3-CR20 through A3-R25. Amplifier A3-IC3 thus senses a system unbalance, operates A3-Q9 which turns A3-Q7 on, and the +12 output begins to rise. This action continues until the current summation at A3-IC3 pin 4 is zero, whereupon the +12 volt output will hold at the voltage level set by A3-R28. Output filter capacitors A3-C14 and A3-C15 aid in reducing the impedance of the regulator. A3-Q8 is a current limit control. As more current is drawn

through A3-Q7, an increasing voltage appears across A3-R20. When this voltage reaches approximately 0.7 volt, A3-Q8 turns on and clamps A3-Q7 base to A3-Q7 emitter. This clamp impedance is much lower than that of A3-R22 and ensures that the operation of A3-IC3 and A3-Q9 is negated.

The -12 volt regulator operates identically to the +12 volt system except that the operating level is determined by current summation of A3-R35 and A3-R36 at point A3-IC4 pin 4.

Plus and minus 24-volt regulating amplifiers A3-IC1 and A3-IC2 are referenced from the +12 volt output. The -24 volt supply voltage is determined by the +12 volt level by summing resistors A3-R16 and A3-R15. The +24 volt level is regulated by the -24 volt supply through resistors A3-R8 and A3-R9. Circuit operation of the 24 volt system is identical to that described for the +12 volt supply.

The plus and minus 5-volt regulating amplifiers A3-IC5 and A3-IC6 are referenced from the +12 volt output. The -5 volt supply voltage is determined by the +12 volt level by summing resistors A3-R53 and A3-R55 and adjusted by potentiometer A3-R54. The +5 volt level is regulated by the -5 volt supply through resistors A3-R46 and A3-R47. Circuit operation of the 5-volt system is identical to that described for the +12 volt supply except for the raw power required by the integrated circuit.

Section V
CALIBRATION AND MAINTENANCE

5-1. INTRODUCTION

This section describes the procedures for proper maintenance and repair of the function generator. Included are performance checks, calibration and adjustment information, and a troubleshooting guide. Periodic maintenance is recommended; however, the overall stability and reliability of the instrument is such that, if used properly, it will provide years of uninterrupted service.

This section of the manual is divided into three basic areas: (1) performance verification, (2) calibration and adjustment, and (3) test point measurements and troubleshooting guide.

5-2. TEST EQUIPMENT REQUIRED

Table 5-1 lists the test equipment required to perform the procedures given in this section. The table includes the types of instruments required, their minimum specifications, and recommended models. If the recommended model is not available, any model which meets the minimum specifications may be substituted.

5-3. PERFORMANCE CHECKS

The following performance checks are designed to assist in comparing the function generator with its published specifications. These checks may be used for incoming inspection, periodic maintenance, and after-repair checks. The performance checks should be made before calibrating the instrument. If the instrument does not meet the requirements outlined in the performance checks, refer to the calibration procedure, paragraph 5-4, in this section.

Performance check data tables are provided throughout this section for recording the performance of the function generator during the performance checks. These tables may be duplicated and used to provide a permanent record if desired.

The performance check procedure consists of the following individual tests:

- Dial Accuracy Check
- Sinewave Frequency Response Check
- Sinewave Distortion Check
- Waveform Symmetry Check
- Squarewave and Pulse Overshoot and Rise-Time Check
- Offset Control Check
- Output Attenuator Check
- Variable Pulse Width Check
- VCG Input Check
- Trigger Sync Check

TABLE 5-1. TEST EQUIPMENT REQUIRED

Type	Suggested Model	Minimum Specifications
Oscilloscope	Tektronix 585A	DC to 80 MHz
Oscilloscope Plug-In	Tektronix Type 1A5 with Type 81 Adapter	Differential Comparator 50 MHz
Oscilloscope Plug-In	Tektronix Type 82	Dual-Trace
Oscilloscope Probe	Tektronix Type P6008	X10 DC to 100 MHz
Oscilloscope Probe	Tektronix Type P6028	X1 DC to 33 MHz
Digital Voltmeter	Darcy 440	0.1 percent Accuracy, 0.1 mv resolution
Counter	Monsanto	5 Hz to 10 MHz, 5 Digits
Time Interval Counter	HP-5223L	0.1 percent Accuracy
DC Voltage Source	Conventional regulated bench supply	Variable - 10 mv resolution
Distortion Analyzer	HP-331A	0.1 percent Full Scale 5 Hz to 600 kHz
Spectrum Analyzer	HP-8553L/8552L Display 140S	100 MHz 1 percent Accuracy
Pulse Generator	Electro Design PG-20	10 Hz to 10 MHz 5 ns Rise Time
Thermal Converter	HP-11049A	20 Hz to 10 MHz 0.1 percent Accuracy
BNC Attenuator	Tektronix 011-0069-01	2X Attenuator
50-ohm Termination	Tektronix 011-0049-01	50-ohm Feedthrough Termination
Voltmeter (Hi-freq)	Boonton 91C	100 kHz to 20 MHz 1 percent Accuracy

- Phase-Lock Check‡
- Sweep Frequency Limit Check

a. DIAL ACCURACY CHECK.

Step 1. Connect the 50 Ω OUTPUT terminal of the function generator to a counter through a 50-ohm feed-through terminal.

Step 2. Set the WAVEFORM switch at ⊓ .

Step 3. Set the OFFSET switch at ∿ .

Step 4. Press the CONT MODE pushbutton.

Step 5. Set the ATTENUATOR switch for 0 db.

Step 6. Set the frequency dial at the indicated values in table 5-2.

Step 7. Set the MULTIPLIER switch at the indicated values in table 5-2.

Step 8. The counter should read within the limits specified in table 5-2 for each indicated frequency.

Step 9. Set the WAVEFORM switch at ⋀ .

Step 10. The counter should read within the limits specified in table 5-3.

b. SINEWAVE FREQUENCY RESPONSE CHECK. - This procedure checks for signal amplitude variations within the tolerance limits. A thermal converter is used in this measurement because its operation is virtually independent of frequency. The percent of change of the thermal converter output should be about 1.7 times the percent of change of the input. Check the calibration report for the exact multiplier factor supplied with the thermal converter. Allow five seconds for the thermal converter to stabilize between readings.

Step 1. Set the OFFSET switch to ∿ .

Step 2. Press the CONT MODE pushbutton.

Step 3. Set the frequency to 10 kHz.

Step 4. Set the WAVEFORM switch to ∿ .

Step 5. Using an oscilloscope, set the ATTENUATOR switch to 10 volts p-p on the 50 Ω OUTPUT with a 50-ohm load.

Step 6. Connect the equipment as shown in figure 5-1.

NOTE

The HP11049A thermal converter is rated for a maximum input of 3.0 vrms. Be careful not to exceed this input at any time.

Step 7. Measure the output voltage from the thermal converter.

Step 8. The maximum meter change converted from percent accuracy deviation is given by the following equation.

$$\text{Max. Meter Change} = \frac{\text{Percent Accuracy}}{100} \times \text{Multiplier Factor} \times \text{Meter Reading}$$

Example: Accuracy = 1%
Multiplier Factor = 1.7
Meter Reading = 10 mv

Maximum change allowed to be within

$$1\% = \frac{1}{100} \times 1.7 \times 10 \text{ ma} = 0.17 \text{ mv}$$

‡The Model F54 does not provide the phase-lock feature.

TABLE 5-2. DIAL ACCURACY VERIFICATION

Dial	Multiplier	Counter Reading	
		Low Limit	High Limit
0.5	0.001	1653 sec	2532 sec
5	0.001	194 sec	206 sec
10	0.001	98 sec	102 sec
0.5	0.01	165 sec	253 sec
5	0.01	19.4 sec	20.6 sec
10	0.01	9.8 sec	10.2 sec
0.5	0.1	16.5 sec	25.3 sec
5	0.1	1.94 sec	2.06 sec
10	0.1	0.98 sec	1.02 sec
0.5	1	1.65 sec	2.53 sec
5	1	0.194 sec	0.206 sec
10	1	0.098 sec	0.102 sec
0.5	10	165 m sec	253 msec
5	10	19.4 m sec	20.6 m sec
10	10	9.8 m sec	10.2 m sec
0.5	100	39.5 Hz	60.5 Hz
5	100	485 Hz	515 Hz
10	100	980 Hz	1020 Hz
0.5	1 K	395 Hz	605 Hz
5	1 K	4.85 kHz	5.15 kHz
10	1 K	9.8 kHz	10.2 kHz
0.5	10 K	3.95 kHz	6.05 kHz
5	10 K	48.5 kHz	51.5 kHz
10	10 K	98 kHz	102 kHz
0.5	100 K	39.5 kHz	60.5 kHz
5	100 K	485 kHz	515 kHz
10	100 K	950 kHz	1050 kHz
0.5	1 M	285 kHz	715 kHz
5	1 M	4.65 MHz	5.35 MHz
10	1 M	9.2 MHz	10.8 MHz

TABLE 5-3. DIAL ACCURACY FOR RAMP AND PULSE WAVEFORMS

Dial	Multiplier	Counter Reading	
		Low Limit	High Limit
0.5	100 k	39.5 kHz	60.5 kHz
5	100 k	485 kHz	515 kHz
10	100 k	890 kHz	1110 kHz
0.5	1 M	350 kHz	650 kHz
5	1 M	4.4 MHz	5.6 MHz

Step 9. To obtain the percent of variation from a change in the meter reading use the following equation.

$$\% \text{ Variation} = \frac{\text{Change in Meter Reading} \times 100}{\text{Multiplier Factor} \times \text{Meter Reading}}$$

Example: $\% = \frac{0.17 \text{ mv}}{1.7 \times 10 \text{ mv}} \times 100$

$\% = 1\%$

Step 10. Measure the amplitude change in the frequency ranges listed in table 5-4 and calculate the percent of variation.

c. SINEWAVE DISTORTION CHECK.

Step 1. Set the frequency dial to 10.

Step 2. Press the CONT MODE pushbutton.

Step 3. Set the MULTIPLIER switch to 1 K.

Step 4. Set the OFFSET switch to ∿ .

Step 5. Set the WAVEFORM switch to ∿ .

Step 6. Connect the 50 Ω OUTPUT terminal to the distortion analyzer using a 50-ohm coaxial cable.

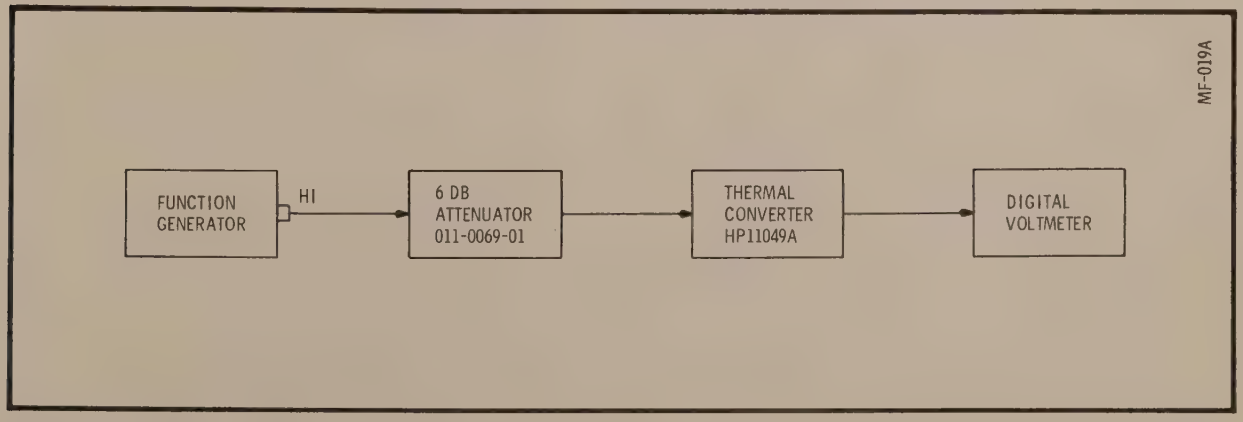


Figure 5-1. Frequency Response Test Setup

TABLE 5-4. FREQUENCY RESPONSE VARIATION

Frequency	Meter Reading	Percent Variation	Allowable Variation
0.0005 MHz to 100 kHz			±0.5 percent
100 kHz to 1 MHz			±1.0 percent
1 MHz to 5 MHz			±3.0 percent
5 MHz to 10 MHz			±5.0 percent

Step 7. Terminate the calbe with the 50-ohm feed-through termination.

Step 8. Set the ATTENUATOR switch to 10 volts p-p using an oscilloscope on the 50 Ω OUTPUT.

Step 9. Set the analyzer controls to read the harmonic content of the 10-kHz signal. Harmonic distortion should be less than 0.5 percent.

Step 10. Make distortion measurements at the frequencies listed in table 5-5.

Step 11. The HP-331A distortion analyzer is useful only to 600 kHz; a spectrum analyzer should be used to check the harmonic content in the megahertz region.

NOTE

The HP-8553L spectrum analyzer input impedance is 50 ohms; therefore, the feed-through terminator should not be used with it. Also, be careful to keep the signal level into the instrument at less than 1 vrms.

d. WAVEFORM SYMMETRY CHECK.

Step 1. Set the frequency to a value in each frequency range specifed in table 5-6.

Step 2. Press the CONT MODE pushbutton.

Step 3. Connect both inputs of the time interval to the function generator SYNC OUT terminal with a 50-ohm feed-through termination.

Step 4. Set channel A to +0.5 volt.

Step 5. Set channel B to -0.5 volt.

Step 6. Record time interval measurement in table 5-6.

Step 7. Set channel A to -0.5 volt.

Step 8. Set channel B to +0.5 volt.

Step 9. Record time interval measurement in table 5-6.

Step 10. The time measurements in steps 6 and 9 should be within the tolerance specified in table 5-6.

e. SQUAREWAVE, PULSE OVERSHOOT, AND RISE-TIME CHECK.

Step 1. Set the frequency to 1 MHz.

Step 2. Press the CONT MODE pushbutton.

Step 3. Set the OFFSET switch to .

TABLE 5-5. SINEWAVE DISTORTION

Frequency	Measured Distortion	Allowable Distortion
0.0005 Hz to 100 kHz		< 0.5 percent (-46 db)
100 kHz to 1 MHz		< 1 percent (-40 db)
1 MHz to 5 MHz		< 3 percent (-30 db)
5 MHz to 10 MHz		< 5 percent (-25 db)

TABLE 5-6. WAVEFORM SYMMETRY

Frequency	Positive Slope	Negative Slope	Tolerance
0.0005 Hz to 10 Hz			< 1.0 percent
10 Hz to 100 kHz			< 0.5 percent
100 kHz to 3 MHz			< 2.0 percent
3 MHz to 10 Hz			< 5 percent

Step 4. Set the WAVEFORM switch to ⊓ .

Step 5. Connect a scope to the 50 Ω OUTPUT terminal by means of a 50-ohm coaxial cable and a 50-ohm feed-through terminator.

Step 6. Set the ATTENUATOR switch to 10 volts p-p.

Step 7. Observe the 10-volt p-p waveform for rise time and overshoot. Rise and fall times should not exceed 30 nsec.

Step 8. The overshoot should be less than 0.5 volt.

Step 9. Set the WAVEFORM switch to ⊓ and repeat step 7.

f. OFFSET CONTROL CHECK.

Step 1. Set the frequency to 1 kHz.

Step 2. Set the WAVEFORM switch to ⊓ .

Step 3. Press the CONT MODE pushbutton.

Step 4. Set the OFFSET switch to ∿ .

Step 4. Connect the 50 Ω OUTPUT of the function generator to the oscilloscope. Use the 50-ohm termination at the oscilloscope input.

Step 6. Adjust the ATTENUATOR switch to obtain a scope display of 10 volts p-p; using the DC input setting.

Step 7. Turn the OFFSET switch to the ∿ position.

Step 8. The waveform should now appear at half amplitude, with its positive peaks at the zero voltage level.

Step 9. Rotate the OFFSET switch to the ∿ position and verify that the negative peaks of the waveform are at the zero voltage level.

g. OUTPUT ATTENUATOR CHECK.

Step 1. Set the frequency to 1 kHz.

Step 2. Set the WAVEFORM switch to ∿

Step 3. Set the OFFSET switch to ⏦

Step 4. Press the CONT MODE pushbutton.

Step 5. Connect a scope to the 50Ω OUTPUT terminal with a type W plug-in.

Step 6. Set the OUTPUT ADJUST control to the CAL position.

Step 7. Connect a 50-ohm feed-through to the oscilloscope.

Step 8. Set the ATTENUATOR switch to the positions listed in table 5-7.

Step 9. The Vpp output voltage level should read within the limits specified in table 5-7.

TABLE 5-7. OUTPUT ATTENUATOR CALIBRATION

Position	50 Ω Output (into 50 Ω)	Tolerance
MAX	15 Vpp	None
0 db	10 Vpp	±2%
-10 db	3.16 Vpp	±2%
-20 db	1.0 Vpp	±2%
-30 db	0.316 Vpp	±2%
-40 db	0.1 Vpp	±2%
-50 db	0.0316 Vpp	±2%

h. VARIABLE WIDTH PULSE CHECK.

Step 1. Set the frequency dial to 10.0.

Step 2. Set the OFFSET switch to ⏦

Step 3. Set the WAVEFORM switch to VAR ⎍.

Step 4. Set the MULTIPLIER switch to 100.

Step 5. Press the CONT MODE pushbutton.

Step 6. Connect channel A of a dual trace oscilloscope to the 50Ω OUTPUT terminal.

Step 7. Connect channel B to SYNC OUT.

Step 8. Rotate the VAR PULSE control between its extreme positions.

Step 9. Set the ATTENUATOR switch to MAX and the OUTPUT ADJUST control to the CAL position.

Step 10. Observe a waveform having a duty cycle which is variable from at least 5 percent to 95 percent of the 1-ms period of the waveform.

Step 11. Set the MULTIPLIER switch to 100K.

Step 12. Vary the setting of the VAR PULSE control and observe that the minimum pulse width is 100 ns or less, measured at half amplitude.

Step 13. Rotate the VAR PULSE control the other end and observe that the minimum pulse width is 100 ns or less, measured at half amplitude.

Step 14. Set the MULTIPLIER switch to 1M.

Step 15. Set the frequency to 5.

Step 16. Connect an oscilloscope through a 50-ohm terminal and observe the variable pulse.

Step 17. The minimum voltage amplitude should be 12 volts p-p.

i. VCG INPUT CHECK.

Step 1. Set the frequency dial at its lower stop.

Step 2. Set the MULTIPLIER switch to 100.

Step 3. Connect a +10 volt variable source to the VCG INPUT.

Step 4. Connect a frequency counter to the SYNC OUT terminal.

Step 5. Connect a digital voltmeter to the VCG INPUT.

Step 6. A voltage of +10.0 ±0.7 volts should be applied for a frequency of 1.000 kHz.

j. TRIGGER SYNC CHECK.

Step 1. Connect a frequency counter to the SYNC OUT terminal of the function generator.

Step 2. Press the CONT MODE pushbutton.

Step 3. Set the function generator to 1000 ±2 Hz.

Step 4. Connect the counter to a pulse generator.

Step 5. Adjust the pulse generator amplitude to +10.0 volt.

Step 6. Set the pulse generator to 1010 ±2 Hz.

Step 7. Connect the + output of the pulse generator to the TRIGGER SYNC terminal.

Step 8. Set the OFFSET switch to .

Step 9. Prepare the oscilloscope with the dual trace plug-in.

Step 10. Connect channel A to the pulse generator.

Step 11. Connect channel B to the function generator 50Ω OUTPUT terminal.

Step 12. Set the WAVEFORM switch to .

Step 13. Adjust the ATTENUATOR switch for identical scope presentations.

Step 14. Externally trigger the scope from the pulse generator sync output terminal.

Step 15. Observe that the function generator output locks to the frequency of the pulse generator.

Step 16. Set the function generator to 1.000 MHz ±0.002 MHz.

Step 17. Set the pulse generator frequency to 1.010 MHz ±0.002 MHz.

Step 18. Set the pulse generator amplitude to +5 volts.

Step 19. Observe that the function generator locks to the pulse generator frequency.

Step 20. Press the TRIG MODE pushbutton.

Step 21. Set the pulse generator frequency to 100 kHz.

Step 22. Observe that pulse generator triggers the function generator output waveform.

k. PHASE-LOCK CHECK.‡

Step 1. Set the frequency dial to 5.

Step 2. Set the MULTIPLIER switch to 100.

Step 3. Set the PHASE CONTROL to the center of its rotation.

Step 4. Apply a 5-volt, p-p, 500 Hz, squarewave input signal to the TRIGGER SYNC terminal.

Step 5. Set the OFFSET switch to ⏦.

Step 6. Set the WAVEFORM switch to ⎍.

Step 7. Press the ϕ LOCK pushbutton.

Step 8. Connect channel A of the dual trace oscilloscope to the input squarewave signal.

Step 9. Connect channel B of the oscilloscope to the 50Ω OUTPUT terminal.

Step 10. Externally trigger the dual trace oscilloscope by using the SYNC OUT terminal.

Step 11. Verify that phase-lock has been achieved by simultaneously observing the waveforms of the two signal sources on the dual trace oscilloscope.

Step 12. If the two units are locked, the traces should appear stationary and at the same frequency, and the output signal should track the input frequency.‡

l. SWEEP FREQUENCY LIMIT CHECK.

Step 1. Set the OFFSET switch to ⏦.

Step 2. Set the WAVEFORM switch to ∿.

Step 3. Connect a counter to the 50Ω OUTPUT terminal.

Step 4. Set the frequency dial to 1.0.

Step 5. Set the black SWEEP LIGHT cursor to 10.0.

Step 6. Set the MULTIPLIER switch to 1K.

Step 7. Set the SWEEPS/SEC switch to 100 Hz and the VERNIER to the CAL position.

Step 8. Press the SWEEP CONT pushbutton.

Step 9. Press and hold the SWEEP CAL pushbutton in performing step 10.

Step 10. The counter should read 10 kHz ±100 Hz.

Step 11. Press and hold the SWEEP RESET pushbutton in performing step 12.

Step 12. The counter should read 1 kHz ±20 Hz.

Step 13. Connect an oscilloscope with a 50-ohm termination to the SWEEP MON terminal.

‡ The Model F54 does not provide the phase-lock feature.

Step 14. Observe a nominal 2-volt p-p waveform (0-vdc baseline).

Step 15. Set the WAVEFORM switch to SWP.

Step 16. Connect an oscilloscope (with a 50-ohm termination) to the 50Ω OUTPUT terminal.

Step 17. Set the ATTENUATOR switch to 0 db and the OUTPUT ADJUST control to the CAL position.

Step 18. Observe a nominal 5.0-volt p-p waveform (0-vdc baseline).

Step 19. Connect an oscilloscope (with a 50-ohm termination) to the SWEEP SYNC terminal.

Step 20. Observe a SWEEP SYNC output pulse of 2 volts p-p about ground.

5-4. ADJUSTMENT AND CALIBRATION PROCEDURE

The following paragraphs contain a complete adjustment and calibration procedure for the function generator. This procedure should be performed only if it has been determined by the performance checks, paragraph 5-3, that the instrument is not operating within the published specifications. Voltage measurements are referenced to chassis ground. Adjustment locations are shown in figure 5-2 and test point locations in figure 5-3.

The detailed calibration procedures which are given below should be performed in the following order:

- Power Supply Calibration
- Dial Calibration
- Waveform Symmetry Calibration
- Triangle Amplitude Calibration
- Triangle Amplifier Gain Calibration
- Inverter DC Balance Calibration
- Compensated Level Control Calibration
- High Frequency Ramp Calibration
- Frequency Calibration
- Start/Stop Amplifier Calibration
- Sine Shaper Calibration
- Squarewave Amplitude Calibration
- Attenuator Calibration
- Output Summing Amplifier Calibration
- Output Amplifier Response Calibration
- Output Offset Calibration
- Phase-Lock Calibration‡
- Sweep Waveform Calibration
- Sweep Limit Calibration

a. POWER SUPPLY CALIBRATION.

Step 1. Connect a digital voltmeter and oscilloscope to A3-TP3 and A3-TP4 (ground).

Step 2. Adjust potentiometer A3-R28 until the voltmeter indicates +12.00 volts ±5.0 mv.

Step 3. The ripple waveform should be less than 10 mv p-p.

Step 4. Connect a digital voltmeter to A3-TP7 and A3-TP4 (ground).

Step 5. Adjust A3-R54 for a voltmeter reading of -5.00 ±0.01 volts.

Step 6. Using the voltmeter and oscilloscope, measure the voltages at the test points listed in table 5-8.

‡ The Model F54 does not provide the phase-lock feature.

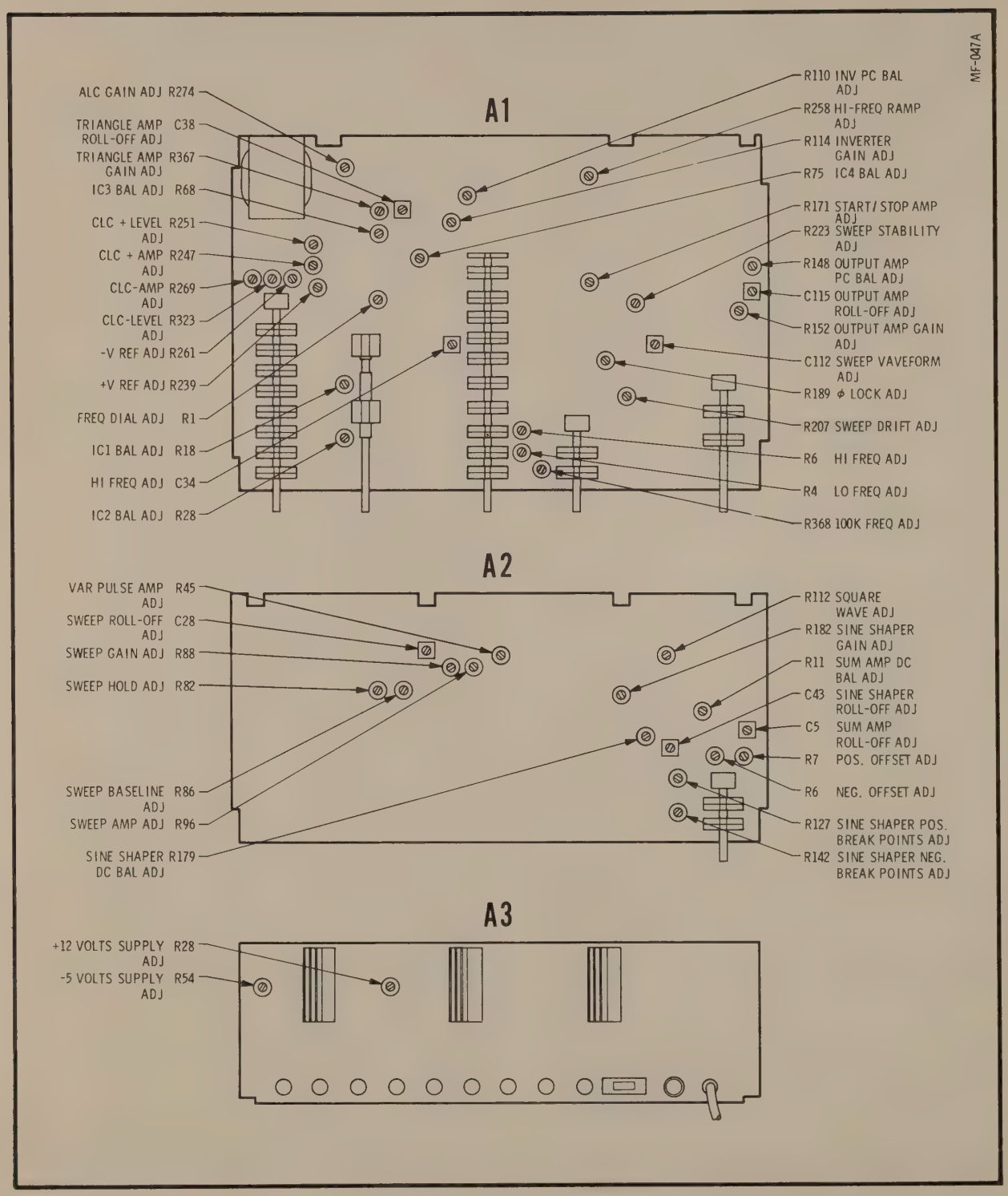

MF-047A
A1
ALC GAIN ADJ R274
TRIANGLE AMP ROLL-OFF ADJ C38
TRIANGLE AMP GAIN ADJ R367
IC3 BAL ADJ R68
CLC + LEVEL ADJ R251
CLC + AMP ADJ R247
CLC-AMP ADJ R269
CLC-LEVEL ADJ R323
-V REF ADJ R261
+V REF ADJ R239
FREQ DIAL ADJ R1
IC1 BAL ADJ R18
HI FREQ ADJ C34
IC2 BAL ADJ R28
R110 INV PC BAL ADJ
R258 HI-FREQ RAMP ADJ
R114 INVERTER GAIN ADJ
R75 IC4 BAL ADJ
R171 START/STOP AMP ADJ
R223 SWEEP STABILITY ADJ
R148 OUTPUT AMP PC BAL ADJ
C115 OUTPUT AMP ROLL-OFF ADJ
R152 OUTPUT AMP GAIN ADJ
C112 SWEEP VAVEFORM ADJ
R189 ϕ LOCK ADJ
R207 SWEEP DRIFT ADJ
R6 HI FREQ ADJ
R4 LO FREQ ADJ
R368 100K FREQ ADJ
A2
VAR PULSE AMP ADJ R45
SWEEP ROLL-OFF ADJ C28
SWEEP GAIN ADJ R88
SWEEP HOLD ADJ R82
SWEEP BASELINE ADJ R86
SWEEP AMP ADJ R96
SINE SHAPER DC BAL ADJ R179
R112 SQUARE WAVE ADJ
R182 SINE SHAPER GAIN ADJ
R11 SUM AMP DC BAL ADJ
C43 SINE SHAPER ROLL-OFF ADJ
C5 SUM AMP ROLL-OFF ADJ
R7 POS. OFFSET ADJ
R6 NEG. OFFSET ADJ
R127 SINE SHAPER POS. BREAK POINTS ADJ
R142 SINE SHAPER NEG. BREAK POINTS ADJ
A3
+12 VOLTS SUPPLY ADJ R28
-5 VOLTS SUPPLY ADJ R54

Figure 5-2. Adjustment Locations

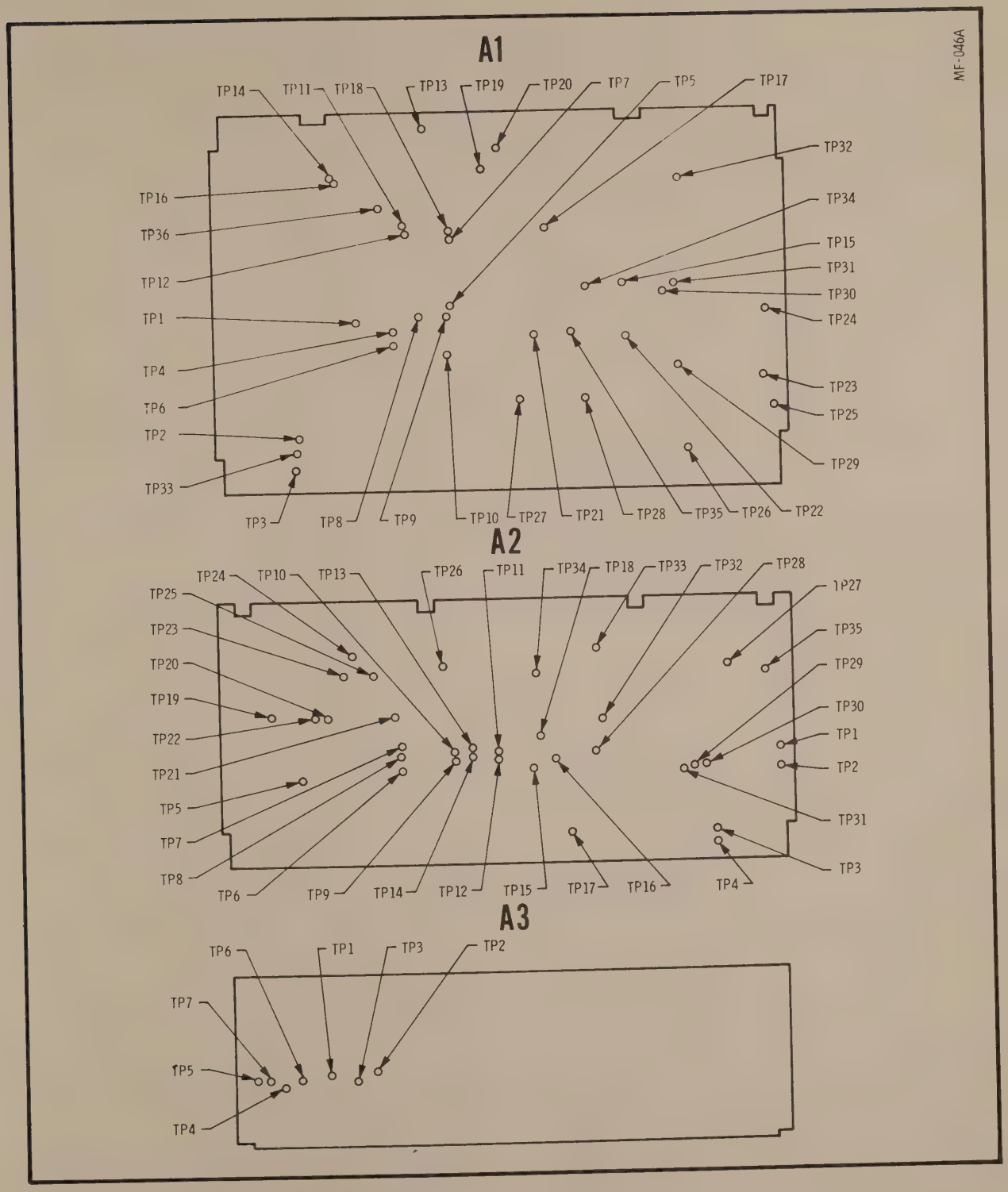


Figure 5-3. Test Point Locations

TABLE 5-8. POWER SUPPLY VOLTAGES

Test Point	Expected Voltage	Tolerance	Maximum Ripple (Millivolts)
A3-TP3	+12.00 vdc	±10 mv	10
A3-TP7	-12.00 vdc	±60 mv	10
A3-TP1	+24.00 vdc	±120 mv	20
A3-TP4	-24.00 vdc	±150 mv	20
A3-TP2	+5.00 vdc	±200 mv	5
A3-TP3	-5.00 vdc	±10 mv	5

Step 7. If any of the voltage measurements are out of tolerance, correct the trouble before continuing with the calibration procedure.

b. DIAL CALIBRATION.

Step 1. Set the potentiometer A1-R1 to the midrange position.

Step 2. Set the frequency dial fully clockwise until cursor indicator lines up with the 1 portion of the 0.1 dial mark.

Step 3. Connect the digital voltmeter between A1-TP1 and A1-TP33 (ground).

Step 4. Loosen the hex nut on potentiometer A1-R3 and hold A1-R3 while performing the next step.

Step 5. Turn the frequency dial slowly clockwise while observing that the voltmeter indicates a voltage decreasing linearly to less than 120 mv. (The body of A1-R3 may require rotating to obtain less than 120 mv.)

Step 6. With the frequency dial set at 0.1, adjust the body of potentiometer A1-R3 until the voltmeter indicates 145 ±5 mv.

Step 7. Holding the body of potentiometer A1-R3 (of step 6), secure the hex nut and again measure the voltage at A1-TP1.

Step 8. If step 7 is out of the acceptable limits, repeat steps 1 through 7.

c. WAVEFORM SYMMETRY CALIBRATION.

Step 1. Connect the digital voltmeter between A1-TP5 and A1-TP3.

Step 2. Adjust potentiometer A1-R18 until the voltmeter indicates +0.050 volt ±5 mv.

Step 3. Set the MULTIPLIER switch to 100.

Step 4. Set the frequency dial to 5.

Step 5. Connect a floating digital voltmeter between A1-TP8 and A1-TP3.

Step 6. Record the voltmeter reading.

Step 7. Reconnect the voltmeter between A1-TP6 and A1-TP2.

Step 8. Adjust potentiometer A1-R28 to obtain a voltmeter indication equal to the previous reading within ±2 mv.

Step 9. Connect a floating digital voltmeter between A1-TP4 and A1-TP6.

Step 10. Adjust potentiometer A1-R68 until an indication of 0.000 volt ±1 mv is obtained.

Step 11. Disconnect the voltmeter of step 9 and reconnect it between A1-TP5 and A1-TP8.

Step 12. Adjust potentiometer A1-R75 until an indication of 0.000 volt ±1 mv is obtained.

d. TRIANGLE AMPLITUDE CALIBRATION.

Step 1. Set the MULTIPLIER switch to 100.

Step 2. Set the frequency dial to 10.

Step 3. Set potentiometer A1-R274 to its midrange position.

Step 4. Set the WAVEFORM switch to ∿.

Step 5. Connect a digital voltmeter to A1-TP18 and A1-TP34 (ground).

Step 6. Adjust potentiometer A1-R239 to obtain a voltmeter indication of +2.700 ±0.005 volts.

Step 7. Connect the digital voltmeter to A1-TP19 and A1-TP34 (ground).

Step 8. Adjust potentiometer A1-R261 to obtain a voltmeter indication of -2.700 to ±0.005 volts.

Step 9. Set the MULTIPLIER switch to 1M.

Step 10. Set the frequency dial to 3.

Step 11. Connect an oscilloscope with a 1A5 plug-in unit to A1-TP14.

Step 12. Adjust A1-R274 until the triangle waveform negative peak is -3.000 ±0.010 volts.

e. TRIANGLE AMPLIFIER GAIN CALIBRATION.

Step 1. Set the frequency dial to 10.

Step 2. Set the MULTIPLIER switch to 100.

Step 3. Connect an oscilloscope with 1A5 plug-in to A1-TP11 and A1-TP9 (ground) and record the amplitude of the triangle.

Step 4. Connect an oscilloscope to A1-TP14.

Step 5. Adjust A1-R367 to obtain four times the amplitude obtained in step 3, within ±1 percent.

f. INVERTER DC BALANCE CALIBRATION.

Step 1. Set the WAVEFORM switch to ⎍.

Step 2. Connect the digital voltmeter between A1-TP13 and A1-TP9 (ground).

Step 3. Adjust potentiometer A1-R110 until the voltmeter indicates 0.00 ±0.01 volt.

g. COMPENSATED LEVEL CONTROL CALIBRATION.

Step 1. Set the frequency dial to its maximum clockwise position (minimum frequency).

Step 2. Set the MULTIPLIER switch to 1M.

Step 3. Set the black SWEEP LIMIT cursor to 10.0 on the frequency dial.

Step 4. Set the SWEEP/SEC switch to 100 Hz and the VERNIER to the CAL position.

Step 5. Connect a signal generator with a 2 Vpp, 1 kHz squarewave to the TRIGGER SYNC input terminal.

Step 6. Press the SWEEP TRIG pushbutton.

Step 7. Connect an oscilloscope to A1-TP14.

Step 8. Adjust the TRIGGER LEVEL control for waveform presentation on the oscilloscope.

Step 9. Adjust A1-R247 for approximately the same positive peak amplitude of all triangle waves.

Step 10. Adjust A1-R269 for approximately the same negative peak amplitude of all triangle waves.

Step 11. Adjust A1-R251 for a positive average peak triangle amplitude of +3.0 volts.

Step 12. Adjust A1-R323 for a negative average peak triangle amplitude of -3.0 volts.

h. HIGH FREQUENCY RAMP CALIBRATION.

Step 1. Set the OFFSET switch to .

Step 2. Set WAVEFORM switch to .

Step 3. Set the frequency to 3.0 MHz.

Step 4. Connect an oscilloscope to A1-TP14.

Step 5. Adjust A1-R258 for minimum aberrations.

i. FREQUENCY CALIBRATION.

Step 1. Set the WAVEFORM switch to .

Step 2. Connect a counter to SYNC OUT terminal and press the CONT MODE pushbutton.

Step 3. Set the frequency dial to 10.

Step 4. Set the MULTIPLIER switch to 100.

Step 5. Set the OFFSET switch to .

Step 6. Adjust A1-R1 for a frequency of 1000 ±1 Hz.

Step 7. Recheck at frequency dial setting of 0.5, observing a frequency reading of 50 ±5 Hz.

Step 8. Rotate the frequency dial clockwise to its lower stop.

Step 9. Record the frequency indicated on the counter (< 10 Hz).

Step 10. If steps 7 and 9 are not within the tolerance, repeat dial calibration procedure.

Step 11. Set the frequency dial to 8.

Step 12. Set the MULTIPLIER switch to 0.1.

Step 13. Adjust A1-R4 for a period of 1.250 ±0.005 seconds.

Step 14. Set the MULTIPLIER switch to 1K.

Step 15. Adjust A1-R6 for a frequency of 8000 ±5 Hz.

Step 16. Set the MULTIPLIER switch to 10K.

Step 17. Verify that the frequency is 80 kHz ±400 Hz.

Step 18. If step 17 is not satisfactory, readjust potentiometer A1-R6 and repeat steps 14 through 17.

Step 19. Set the MULTIPLIER switch to 1M.

Step 20. Set the frequency dial to 8.

Step 21. Adjust trimmer A1-C34 for an 8.0 MHz indication on the counter.

Step 22. Set the frequency dial to 10.0.

Step 23. Set the MULTIPLIER switch to 1M.

Step 24. Adjust trimmer capacitor A1-C38 for a frequency of 10.0 ±0.03 MHz.

Step 25. Set the frequency to 2.0 MHz.

Step 26. Adjust A1-R274 for a frequency of 2 MHz ±100 kHz.

Step 27. Repeat steps 14 through 26 until dial settings are within tolerance.

Step 28. Set the MULTIPLIER switch to 100K.

Step 29. Adjust A1-R368 for a frequency of 800 ±4 kHz.

j. START/STOP AMPLIFIER CALIBRATION.

Step 1. Set the frequency dial at 10.

Step 2. Set the MULTIPLIER switch to 1K.

Step 3. Set the PHASE and TRIGGER LEVEL controls to the center of their rotation.

Step 4. Press the TRIG MODE and SWEEP BURST pushbuttons.

Step 5. Connect an oscilloscope at A1-TP14.

Step 6. Set the SWEEP/SEC switch to 1K and the VERNIER to the CAL position.

Step 7. If the triggered waveform does not appear, readjust the TRIGGER LEVEL control.

Step 8. Adjust A1-R171 for 0 vdc centerline during the waveform off time.

k. SINE SHAPER CALIBRATION.

Step 1. Set the frequency to 50 kHz.

Step 2. Set the WAVEFORM switch to ∿

Step 3. Set the OFFSET switch to ⏦

Step 4. Connect a short jumper lead between A2-TP29 and A2-TP3 (ground).

Step 5. Connect a short jumper lead from A1-TP11 to A1-TP9 (ground).

Step 6. Connect the digital voltmeter between A2-TP32 and ground.

Step 7. Adjust A2-R179 for 0 volts ±10 mv at A2-TP32.

Step 8. Remove jumper leads on A2-TP29 and A1-TP11.

Step 9. Connect an oscilloscope to the SINE MON terminal.

Step 10. Press the CONT MODE pushbutton.

Step 11. Connect a distortion analyzer or spectrum analyzer to the SINE MON terminal. (NOTE: the HP-8553 spectrum analyzer input impedance is 50 ohms.)

Step 12. Alternately adjust A2-R127 and A2-R142 for minimum total distortion.

Step 13. If the distortion analyzer is used, total harmonic distortion should be less than 0.5 percent.

Step 14. If the spectrum analyzer is used, all harmonics should be -50 db below the fundamental frequency.

Step 15. Connect a type 585A oscilloscope with a type 1A5 plug-in to A2-TP32.

Step 16. Adjust A2-R182 for a positive wave amplitude of +3.0 ±0.015 volts.

Step 17. Connect a high frequency voltmeter to A2-TP32.

Step 18. Set the MULTIPLIER switch to 1M.

Step 19. Rotate the frequency dial from 5 to 10 and adjust A2-C43 for a maximum flat response of 2.08 ±0.06 vrms or a voltmeter deviation reading of ±3 percent.

l. SQUAREWAVE AMPLITUDE CALIBRATION.

Step 1. Set the frequency to 1 kHz.

Step 2. Press the CONT MODE pushbutton.

Step 3. Set the WAVEFORM switch to ⊓ .

Step 4. Connect a type 585A oscilloscope with type 1A5 plug-in to A2-TP27.

Step 5. Adjust A2-R112 for a positive waveform level of +3.0 ±0.015 volts.

m. ATTENUATOR CALIBRATION.

Step 1. Set the frequency to 1 kHz.

Step 2. Set the OFFSET switch to ⊸ .

Step 3. Press the CONT MODE pushbutton.

Step 4. Set the WAVEFORM switch to ∿ .

Step 5. Connect a 585A oscilloscope with a 50-ohm load and type 1A5 plug-in to the 50 OUTPUT terminal.

Step 6. Rotate the OUTPUT ADJUST control to the CAL position.

Step 7. Set the ATTENUATOR switch to 10 Vpp.

Step 8. Adjust A1-R152 for a positive peak waveform level of +5 ±0.025 volts.

n. OUTPUT SUMMING AMPLIFIER CALIBRATION.

Step 1. Set the OFFSET switch to ⏦.

Step 2. Set the frequency dial to 10.0.

Step 3. Set the MULTIPLIER switch to 1K.

Step 4. Set the WAVEFORM switch to SWP.

Step 5. Connect a short jumper between A2-TP2 and A2-TP3 (ground).

Step 6. Connect the digital voltmeter to A2-TP35 and A2-TP3 (ground).

Step 7. Adjust A2-R11 until the voltmeter reads less than ±0.005 volt.

Step 8. Set the ATTENUATOR switch to the 0-db position.

Step 9. Connect a short jumper between A1-TP23 and A1-TP25 (ground).

Step 10. Connect the voltmeter to the 50 Ω OUTPUT terminal.

Step 11. Adjust A1-R148 until the voltmeter reads less than ±0.02 volt.

Step 12. Remove the jumpers installed at A2-TP2 and A1-TP23.

o. OUTPUT AMPLIFIER RESPONSE CALIBRATION.

Step 1. Set the WAVEFORM switch to ∿.

Step 2. Press the CONT MODE pushbutton.

Step 3. Set the MULTIPLIER switch to 1M.

Step 4. Set the frequency dial to 1.0.

Step 5. Set the OFFSET switch to ⏦.

Step 6. Set the ATTENUATOR switch to 0 db and the OUTPUT ADJUST control to the CAL position.

Step 7. Connect a high frequency voltmeter to A2-TP35 and the probe ground to A2-TP3.

Step 8. Measure and record the voltmeter reading.

Step 9. Rotate the frequency dial from 1.0 to 10.0 and adjust A2-C5 for a maximum flat response of the voltmeter reading obtained in step 8 (within a tolerance of 0 to -3 percent.

Step 10. Connect a high frequency voltmeter to the 50 Ω OUTPUT by means of a 50-ohm coaxial cable. Use the 50-ohm feed-through termination adapter at the voltmeter end of the cable.

Step 11. Set the frequency dial to 1.0.

Step 12. Measure and record the voltmeter reading.

Step 13. Rotate the frequency dial from 1.0 to 10.0 and adjust A1-C115 for a maximum flat response for the voltmeter reading obtained in step 12 (within a tolerance of +0 to -5 percent).

p. OUTPUT OFFSET CALIBRATION.

Step 1. Set the frequency to 100 Hz.

Step 2. Set the WAVEFORM switch to ⊓.

Step 3. Set the OFFSET switch to ∿.

Step 4. Press the CONT MODE pushbutton.

Step 5. Connect the 50 Ω OUTPUT of the function generator to the oscilloscope. Use the 50-ohm termination at the oscilloscope input.

Step 6. Adjust the ATTENUATOR switch to obtain an oscilloscope display of 10 volts p-p, using the d-c input setting.

Step 7. Set the OFFSET switch to ∿ .

Step 8. The waveform should now appear at half amplitude, with its positive peaks at the zero voltage level ±50 mv.

Step 9. Adjust A2-R6 to obtain this condition.

Step 10. Rotate the OFFSET switch to the ∿ position and verify that the negative peaks of the waveform are at zero volts ±50 mv.

Step 11. Adjust A2-R7 to obtain this condition.

Step 12. Set the OFFSET switch to ADJ ∿.

Step 13. Rotate the OFFSET ADJUST control fully counter-clockwise. No part of the waveform should cross the zero level in the positive direction.

Step 14. Rotate the OFFSET ADJUST control fully clockwise. No part of the waveform should cross the zero level in the negative direction.

q. PHASE LOCK CALIBRATION.‡

Step 1. Set the frequency dial to 5.

Step 2. Set the MULTIPLIER switch to 100.

Step 3. Set the PHASE control to the center of its rotation.

Step 4. Apply 5-Vpp, 500-Hz, squarewave input signal to the TRIGGER SYNC terminal.

Step 5. Set the OFFSET switch to ∿.

Step 6. Set the WAVEFORM switch to ⊓.

Step 7. Press the ϕ LOCK pushbutton.

Step 8. Connect channel A of a dual trace oscilloscope to the input squarewave signal.

Step 9. Connect channel B to the 50 Ω OUTPUT terminal.

Step 10. Externally trigger the oscilloscope, using the SYNC OUT terminal.

Step 11. Verify that phase lock has been achieved by simultaneously observing the waveforms of the two signal sources on the dual trace oscilloscope.

‡The Model F54 does not provide the phase-lock feature.

Step 12. If the two units are locked, the traces should appear stationary, and at the same frequency.

Step 13. Connect the oscilloscope to A1-TP22.

Step 14. Adjust A1-R189 for a minimum peak-to-peak voltage amplitude of the waveform.‡

r. SWEEP WAVEFORM CALIBRATION.

Step 1. Set the SWEEPS/SEC switch to 0.1 Hz with the VERNIER at the maximum CCW position.

Step 2. Place a jumper lead from A1-TP27 to A2-TP3 (ground).

Step 3. Short out capacitor A1-C72 with a jumper lead.

Step 4. Place a digital voltmeter on A1-TP28.

Step 5. Adjust A1-R207 for 0.0 ±1.0 mv at A1-TP28.

Step 6. Remove jumper lead at A1-TP27.

Step 7. Set the SWEEPS/SEC switch to 100 Hz and the VERNIER to the CAL position.

Step 8. Press the SWEEP CONT pushbutton.

Step 9. Connect an oscilloscope to A1-TP28.

Step 10. Adjust A1-R223 until a sawtooth peak waveform is obtained at -0.1 ±0.01 volt.

Step 11. Set the SWEEPS/SEC switch to 100 kHz.

Step 12. Adjust A1-C112 for minimum overshoot and ringing in the waveform.

s. SWEEP FREQ LIMIT CALIBRATION.

Step 1. Set OFFSET switch to ⏦.

Step 2. Set WAVEFORM switch to ∿.

Step 3. Connect a counter to the SYNC OUT terminal.

Step 4. Set the frequency dial to 1.0.

Step 5. Set the black SWEEP LIMIT cursor to 10.0.

Step 6. Set the MULTIPLIER switch to 1K.

Step 7. Set the SWEEPS/SEC switch to 100 Hz and the VERNIER to the CAL position.

Step 8. Press the SWEEP CONT pushbutton.

Step 9. Press and hold the SWEEP CAL pushbutton in performing steps 10 and 12.

Step 10. Adjust A2-R82 for a counter frequency of 10 kHz ±100 Hz.

Step 11. Connect a 585A oscilloscope with a 1A5 Type plug-in to A2-TP26.

Step 12. Measure and record the d-c voltage level at A2-TP26 to within 1 percent while pressing the CAL pushbutton.

Step 13. Adjust A2-R88 for the sawtooth waveform peak amplitude equal to the d-c voltage level (±0.04 volt) obtained by pushing

‡The Model F54 does not provide the phase-lock feature.

the SWEEP CAL pushbutton as recorded in step 12.

Step 14. Repeat steps 9 and 10.

Step 15. Set WAVEFORM switch to SWP.

Step 16. Connect an oscilloscope to the 50 Ω OUTPUT with a 50-ohm load.

Step 17. Set the ATTENUATOR switch to the 0 db position and the OUTPUT ADJUST control to the CAL position.

Step 18. Adjust A2-R96 for a sweep waveform of 5.0 volts p-p (0-vdc baseline).

5-5. TROUBLESHOOTING.

The following paragraphs cover most of the individual circuits and are intended to help in the quick repair of the function generator. Refer to the functional block diagram, figure 7-1, and circuit schematics, figures 7-3, 7-5, and 7-7. An illustrative table containing all of the testpoint measurements is also included. The following topics are covered in this section.

- Power Supply
- Voltage Level Sensor and Automatic Level Control
- Triangle Amplifier
- Inverter Amplifier
- Frequency Control and Voltage-to-Current Converter
- Variable Pulse Width Shaper
- Sweep Generator
- Test-Point Measurements

a. POWER SUPPLY TROUBLESHOOTING. - When the power supply is turned on, d-c voltages are established in sequence. The +12 volt supply starts first and provides a reference for the -12 volt supply. When the -12 volt output is established, a power source for the -5 volt regulator is provided. Presence of +12 volts powers the 24-volt regulator amplifiers, and the -24 volt supply will start, collowed by the +24 volt supply. Thus, if +12 volt power is not present, no other voltages can be present. If -12 volt is missing, +24, -24, and -5 will be missing. If -24 volts is not operating, +24 will not operate. The only voltages which do not affect the operation of other voltage regulators are +5 and +24 volts.

In the case of incorrect voltages, the sequence to be followed is +12, -12, +5, -5, -24, and +24. If one or more voltages are incorrect, proceed as follows:

Step 1. Check the pilot lamp for presence of line power and fuse.

Step 2. Check for presence of d-c voltages according to the sequence listed.

Step 3. Check for a possible short or overcurrent on the affected supply. A3-Q2, A3-Q5, A3-Q8, A3-Q11, A3-Q14, A3-Q17 provide current limiting which reduces the 5, 12 and 24-volt lines to zero when overloads are present.

Step 4. If low voltages are present in the 5, 12, or 24-volt systems and no overload currents are present:

(1) Check overload transistors A3-Q2, A3-Q5, A3-Q8, A3-Q11, A3-Q14, and A3-Q17 for leakage or shorts.

(2) Check collector leads of A3-Q3, A3-Q4, A3-Q9, A3-Q10, A3-Q15 and A3-Q16. These collectors approach ground potential when an increase in output voltage is sensed by the regulator amplifiers A3-IC1 through A3-IC6.

(3) Check pass transistors A3-Q1, A3-Q6, A3-Q7, A3-Q12, A3-Q13, and A3-Q18 for open collectors. This condition is evident if the base of the pass transistor is 0.6 volt closer to ground than its emitter.

Step 5. If high voltages are present in the 12 or 24-volt systems, check pass transistors A3-Q1, A3-Q6, A3-Q7, A3-Q12, A3-Q13, and A3-Q18 for shorts.

b. VOLTAGE LEVEL SENSOR AND AUTOMATIC LEVEL CONTROL TROUBLESHOOTING. - The most likely cause of abnormal operation is within the VLS, because of its critical speed requirements. Obvious component failure should always be investigated initially, which might typically lead to one of the following:

(1) Improper reference voltages V_R (+) or V_R (-).

(2) Improper clamp voltage +3 or -3 volts.

(3) Incorrect d-c condition in ALC.

(4) Incorrect currents delivered to tunnel diodes.

(5) Failure of the latch circuit to toggle.

If no obvious component failures can be found, waveforms at A1-TP17 and A1-TP20 give the best clues as to causes of improper operation. A1-TP17, at a d-c level of +12 volts, should exhibit a nominal 1-volt negative pulse at the positive triangle peak, and a nominal 3-volt positive pulse at the negative triangle peak.

The waveform at A1-TP20 is a approximately +12.5 volts during the positive going ramp, and at approximately +11.7 volts during the negative going ramp. At the negative peak, a short duration pulse of +11.3 volts is normally present. (Refer to test point waveforms, table 5-10.).

NOTE

If A1-R171 is not properly adjusted, the function generator will not operate; therefore, this control should be checked carefully.

c. TRIANGLE AMPLIFIER TROUBLESHOOTING. - In the event of major difficulty within the triangle amplifier, it is probable that the main integrator will also be inoperative. In this event, ground A1-TP10, then check for correct d-c conditions within the amplifier circuit. Because of the straightforward circuitry, a stage-by-stage d-c check should give adequate clues.

d. INVERTER AMPLIFIER TROUBLESHOOTING. - Similar procedures can be followed for inverter amplifier troubleshooting, because of the similarities of design. In the case of the inverter, a main loop signal may be available to assist, in the event that the triangle amplifier is still operative. If this is the case, simply set the WAVEFORM switch to either a positive-going ramp (◿) or a pulse (⎍) to obtain the test signal.

e. FREQUENCY CONTROL AND VOLTAGE-TO-CURRENT CONVERTER TROUBLESHOOTING. - Because the prime function of the frequency control and voltage-to-current converter is to generate known currents, the first item to check should be current level. This is best accomplished by connecting a low impedance milliameter (or microameter) between A1-TP10 and ground. This action will stall the integrator loop and make d-c measurements possible. The polarity of this current should be the same as the polarity of the voltage present at A1-TP7. Tabel 5-9 lists the maximum current generated on each range, for 50/50 duty cycle functions. (Frequency dial at 10.)

TABLE 5-9. INTEGRATOR CURRENT AT 50/50 DUTY CYCLE VERSUS FREQUENCY MULTIPLIER SETTING

Multiplier	Maximum Current
0.001	300 na
0.01	3 μa
0.1	30 μa
1	3 μa
10	30 μa
100	300 μa
1 K	30 μa
10 K	300 μa
100 K	1.5 ma
1 M	7.5 ma

(1) Following a determination of incorrect current levels, and whether or not they are a function of A1-TP7 polarity, there should now be some clues as to the source of the problem. Note than in order to obtain a desired polarity at A1-TP7, it may be necessary to force the voltage level sensor circuitry into the desired state. This can be accomplished by momentarily clipping a grounded 470-ohm resistor to either A1-TP17 or A1-TP20.

(a) If proper current levels exist for negative polarity, the problem can be isolated to the area of A1-IC3, A1-IC2, A1-S1-5, and A1-S1-3.

(b) If neither polarity at A1-TP7 causes the proper current flow, this points to possible problems with A1-IC1 circuitry.

(2) In the event of less obvious problems, such as poor waveforms at low frequencies, one should suspect excessive leakage current at the integrator. Low frequency operation requires total leakage in the nanoamp region, and any of several components should be suspected, as should the possibility of grease, dirt, or moisture on the circuit board itself.

f. VARIABLE PULSE WIDTH SHAPER TROUBLESHOOTING. - Verify the presence of a 6-volt p-p triangular waveform at the input to A2-R27. Provided the waveform does exist, a nominal 0 to +4 volt pulse should then be present at A2-TP33. The presence of this pulse verifies the operation of comparator A2-IC1. Further signal tracing through the discrete driver circuits A2-Q10 to A2-Q13 should lead to the source of difficulty.

g. SWEEP GENERATOR TROUBLESHOOTING. - A1-IC7 and A1-IC8 generate the basic sweep waveform. Three test point measurements can usually indicate any trouble in generating the sawtooth wave. Test points A1-TP28, A1-TP29, and A1-TP30 should be checked with the test point waveform pictures.

If no waveform is present, the following technique should be used. The test point

voltages are valid measurements and if any test point voltage is incorrect, the circuitry controlling that test point should be suspect. Either CASE I or CASE II (in the following table) are valid conditions for oscillating.

Case I		Case II	
A2-TP20	+0.1 volt	A2-TP20	0.1 volt
A2-TP24	+2 volts	A2-TP24	+2 volts
A1-TP28	-4.1 volts	A1-TP28	0 volts
A1-TP29	-4 volts	A1-TP29	-0.1 volt
A1-TP30	+10 volts	A1-TP30	-20.0 volts

The amplifier A2-IC8 is a unity gain inverting amplifier which contains an offset balance and a d-c input signal. By opening the feedback resistor A2-R87 and connecting it to pin 12 of A2-IC8, the IC8 amplifier may be tested independently.

The NAND gates A2-IC9 and A2-IC10 may be individually tested by momentarily grounding an input and observing a +4 volt level on the gate output. The rule to remember for all NAND gates is that any low input to the gate must drive the output high.

h. TEST POINT WAVEFORMS. - Table 5-10 lists the d-c voltages or signal waveforms at each test point. The test point conditions are as follows unless specified otherwise:

INITIAL CONDITIONS

(1) PWR pushbutton - Depressed
(2) CONT MODE pushbutton - Depressed
(3) Frequency dial - 10
(4) MULTIPLIER switch - 100
(5) Frequency - 1.0 kHz
(6) WAVEFORM switch -
(7) OFFSET switch -
(8) SWEEPS/SEC switch - 1 K
(9) SWEEPS/SEC VERNIER - CAL
(10) ATTENUATOR switch - MAX
(11) OUTPUT ADJUST - CAL

All measurements are made with respect to ground.

TABLE 5-10. TEST POINT MEASUREMENTS

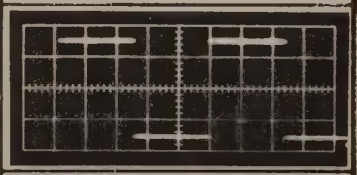
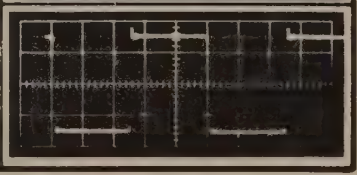
Test Point	Conditions	Comments	Measurement
A1-TP1 (Freq Control)	Note (1)	Read dc	+10 volts
A1-TP2 (V_A)	Note (1)	Read dc	+17.5 volts
A1-TP3 (V_B)	Note (1)	Read dc	-17.5 volts
A1-TP4 (V_C)	Note (1)	Read dc	+7.5 volts
A1-TP5 (V_D)	Note (1)	Read dc	-7.5 volts
A1-TP6 (Positive Current Source)	Note (1)	Read dc	+7.5 volts
A1-TP7 (VLS Output)	Note (1)	H = 0.2 ms/cm V = 2 v/cm + 0.7 Volt level	
	Note (2)	H = 0.2 μs/cm V = 2 v/cm + 0.7 Volt level	

Table 5-10. Test Point Measurements (Continued)

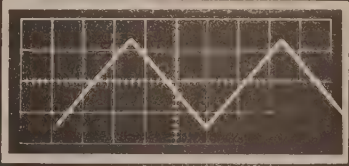
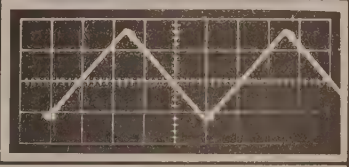
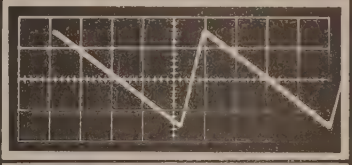
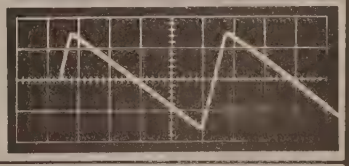
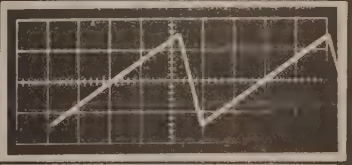
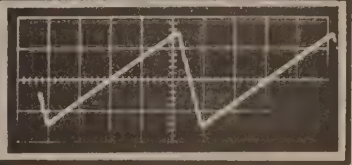
Test Point	Conditions	Comments	Measurement
A1-TP8 (Negative Current Source)	Note (1)	Read dc	-7.5 volts
A1-TP9 (GND)			0 volts
A1-TP10 (Triangle Generator)	Note (1)	H = 0.2 ms/cm V = 0.5 v/cm	
	Note (2)	H = 0.2 μs/cm V = 0.5 v/cm	
A1-TP11	Same as TP 10		
A1-TP12 (Inverter Input)	Note (1) WAVEFORM ✓	H = 0.2 ms/cm V = 2 v/cm	
	Note (2) WAVEFORM ✓	H = 0.2 μs/cm V = 2 v/cm	
A1-TP13 (Inverter Output)	Note (1) WAVEFORM ✓	H = 0.2 ms/cm V = 2 v/cm	
	Note (2) WAVEFORM ✓	H = 0.2 μs/cm V = 2 v/cm	

Table 5-10. Test Point Measurements (Continued)

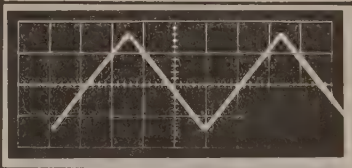
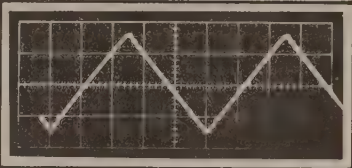
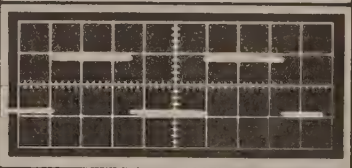
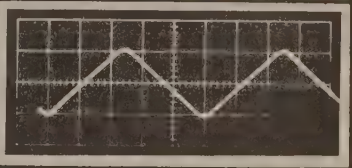
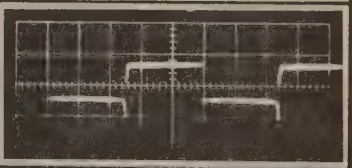
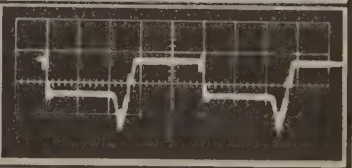
Test Point	Conditions	Comments	Measurement
A1-TP14 (Triangle Amplifier Output)	Note (1)	H = 0.2 ms/cm V = 2 v/cm	
	Note (2)	H = 0.2 ms/cm V = 2 v/cm	
A1-TP15 (ϕ LOCK Input)	Notes (1) and (3) Press ϕ LOCK	H = 0.2 ms/cm V = 2 v/cm	
A1-TP16 (ALC Input)	Note (2)	H = 0.2 μs V = 2 v/cm	
A1-TP17 (Tunnel Diode Triggering)	Note (1)	H = 0.2 ms/ cm V = 0.5 v/cm +12 Volt level	
	Note (2)	H = 0.2 μs/cm V = 0.5 v/cm +12 Volt level	
A1-TP18 ($+V_{Ref}$)	Note (1)	Read dc	+3 volts
	Note (2)	Read dc	+2 volts
	Note (1) MULTIPLIER IM (1 MHz)	Read dc	0 volts

Table 5-10. Test Point Measurements (Continued)

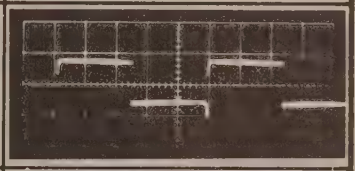
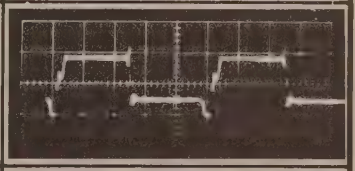
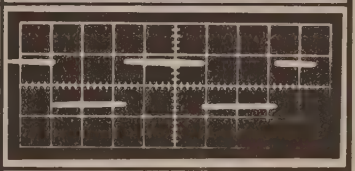
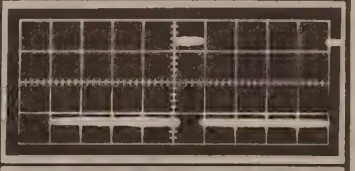
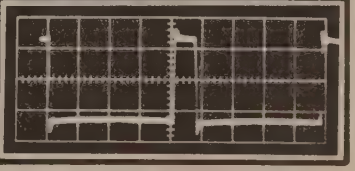
Test Point	Conditions	Comments	Measurement
A1-TP19 ($-V_{Ref}$)	Note (1)	Read dc	-3 volts
	Note (2)	Read dc	-2 volts
	Note (1) MULTIPLIER IM (1 MHz)	Read dc	0 volts
A1-TP20 (Tunnel Diode Triggering)	Note (1)	H = 0.2 ms/cm V = 0.5 v/cm +12 Volt level	
	Note (2)	H = 0.2 μs/cm V = 0.5 v/cm +12 Volt level	
A1-TP21 (ϕ LOCK Filter Output)	Notes (1) and (3) Press ϕLOCK	H = 0.2 ms/cm V = 1 v/cm	
A1-TP22 (ϕ LOCK Output)	Note (1) and (3) Press ϕ LOCK	Read dc	< ± 1.0 volt
A1-TP23 (Output Amplifier Input)	Note (1) WAVEFORM ⎍	H = 0.2 ms/cm V = 2 v/cm	
	Note (2) WAVEFORM ⎍	H = 0.2 μs/cm V = 2 v/cm	

Table 5-10. Test Point Measurements (Continued)

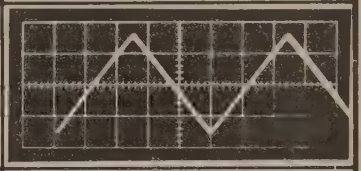
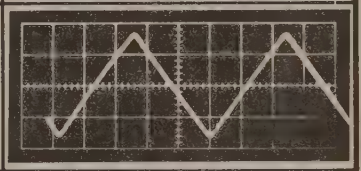
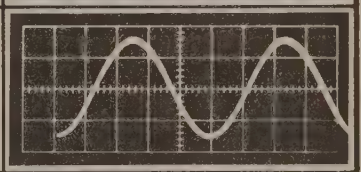
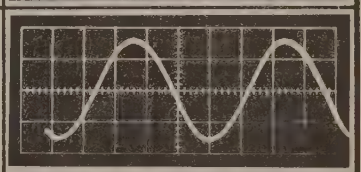
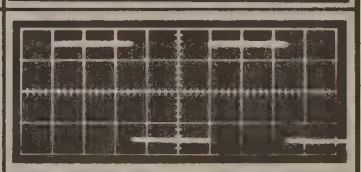
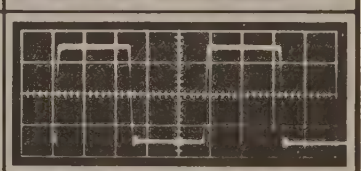
Test Point	Conditions	Comments	Measurement
A1-TP24 (Output Amplifier Output)	Note (1)	H = 0.2 ms/cm V = 10 v/cm	
	Note (2)	H = 0.2 μs/cm V = 10 v/cm	
	Note (1) WAVEFORM ∿	H = 0.2 ms/cm V = 10 v/cm	
	Note (2) WAVEFORM ∿	H = 0.2 μs/cm V = 10 v/cm	
	Note (1) WAVEFORM ⊓⊔	H = 0.2 ms/cm V = 10 v/cm	
	Note (2) WAVEFORM ⊓⊔	H = 0.2 μs/cm V = 10 v/cm	
A1-TP25 (GND)			0 volts
A1-TP26 (GND)			0 volts
A1-TP27 (DC Sweep Control)	Note (1)	Read dc	+12 volts

Table 5-10. Test Point Measurements (Continued)

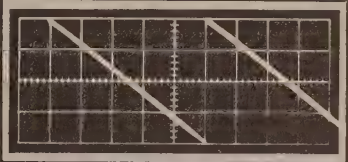
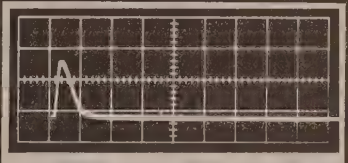
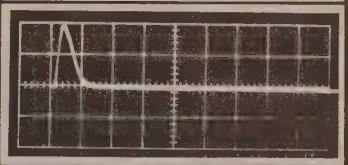
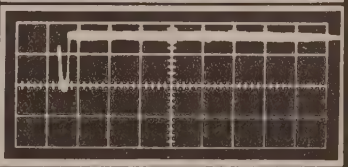
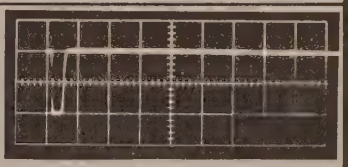
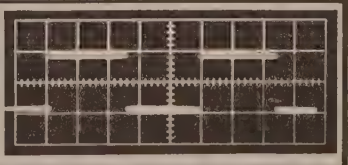
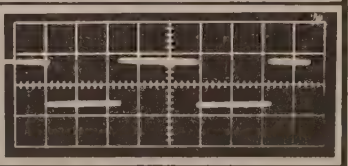
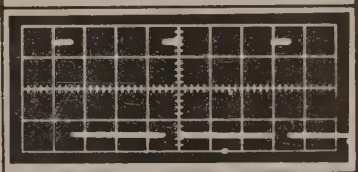
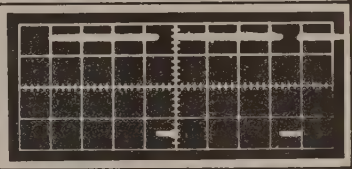
Test Point	Conditions	Comments	Measurement
A1-TP28 (Sweep Integrator Output)	Note (1) Press SWEEP CONT	H = 0.2 ms/cm V = 1 v/cm -2 Volt level	
A1-TP29 (Sweep Pulse Output)	Note (1) Press SWEEP CONT	H = 0.5 μs/cm V = 20 v/cm	
A1-TP30 (SweepReference Voltage)	Note (1) Press SWEEP CONT	H = 0.5 μs/cm V = 2 v/cm -4 Volt level	
A1-TP31 (Sweep Comparator Output)	Note (1) Press SWEEP CONT	H = 0.5 μs/cm V = 2 v/cm	
A1-TP32 (SWEEP SYNC Out)	Note (1) Press SWEEP CONT	H = 0.5 μs/cm V = 2 v/cm	
A1-TP33 (GND)			0 volts
A1-TP34 (Phase-Lock Filter Input)	Notes (1) and (3) Press ϕ LOCK	H = 0.2 ms/cm V = 0.5 v/cm	
A1-TP35 (Phase-Lock Filter Output)	Notes (1) and (3) Press ϕ LOCK	H = 0.2 ms/cm V = 0.1 v/cm	
A1-TP36 (GRD)			0 volts

Table 5-10. Test Point Measurements (Continued)

Test Point	Conditions	Comments	Measurement
A2-TP1 (Output Summing Amplifier Input)	Note (1) WAVEFORM ⌐⌐	H = 0.2 ms/cm V = 2 v/cm	
A2-TP2 (Output Summing Amplifier Input)	Note (1) WAVEFORM ⌐⌐	H = 0.2 ms/cm V = 1 v/cm	
A2-TP3 (GND)			0 volts
A2-TP4 (Offset Adjust)	Note (1) Set to ADJ (Max CW)	Read dc	-12 volts

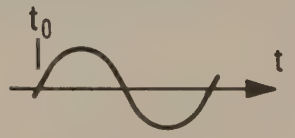
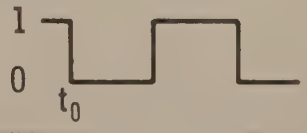
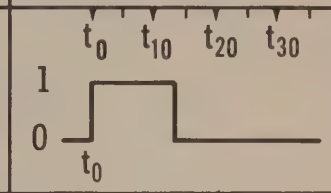
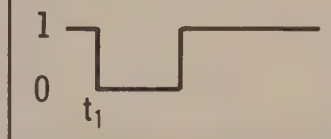
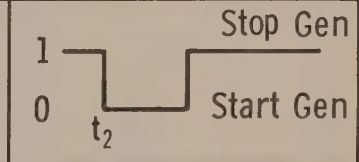
TRIGGER LOGIC SEQUENTIAL TIMING DIAGRAM			
Test Point	Conditions	Comments	Measurement
TRIGGER SYNC Input (BNC)	Notes (1) and (3) TRIGGER LEVEL Centered Press TRIG SLOPE		
A2-TP5	Note (3) Press GATE or BURST	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	

Table 5-10. Test Point Measurements (Continued)

GATE OR BURST MODE SEQUENCE			
Test Point	Conditions	Comments	Measurement
A2-TP7	Note (3) Press GATE or BURST	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP8	Note (3) Press GATE or BURST	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP9	Note (3) Press GATE or BURST	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volts	

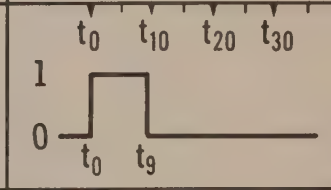
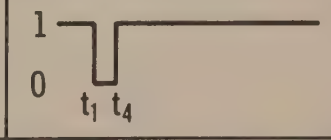
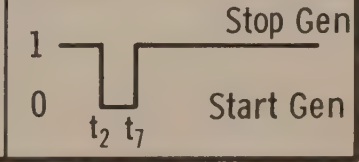
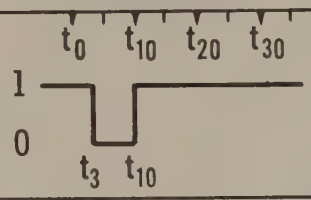
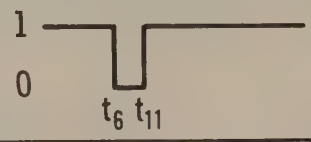
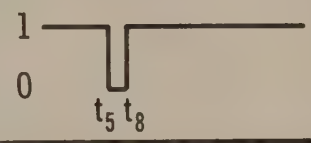
TRIGGER MODE SEQUENCE			
Test Point	Conditions	Comments	Measurement
A2-TP7	Note (3) Press TRIG MODE	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP8	Note (3) Press TRIG MODE	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP9	Note (3) Press TRIG MODE	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	

Table 5-10. Test Point Measurements (Continued)

Trigger Mode Sequence (continued)			
Test Point	Conditions	Comments	Measurement
A2-TP6	Note (3) Press TRIG MODE	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP13	Note (3) Press TRIG MODE	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP10	Note (3) Press TRIG MODE	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	

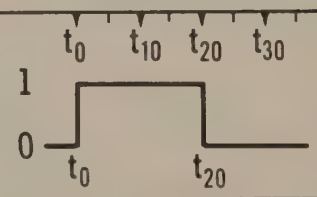
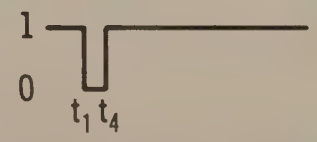
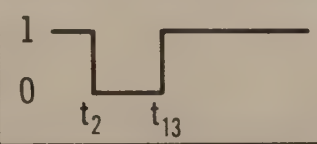
PHASE LOCK SEQUENCE			
Test Point	Conditons	Comments	Measurement
A2-TP7	Note (3) Press ϕLOCK	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP8	Note (3) Press ϕLOCK	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP9	Note (3) Press ϕLOCK	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	

Table 5-10. Test Point Measurements (Continued)

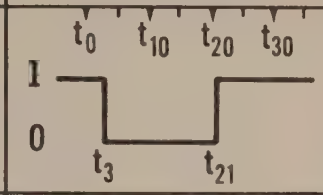
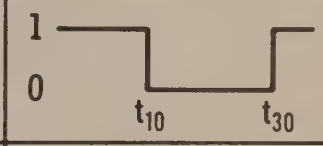
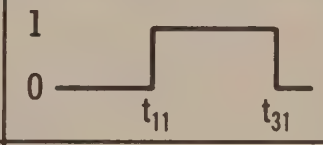
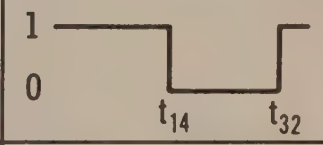
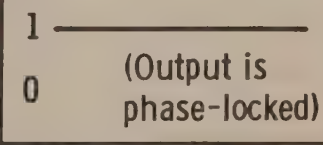
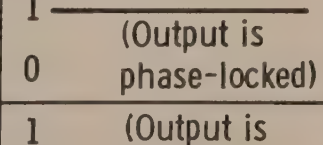
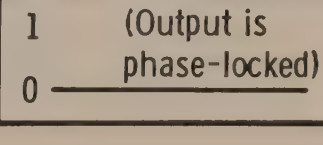
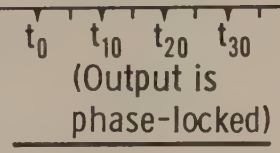
Phase Lock Sequence (continued)			
Test Point	Conditions	Comments	Measurement
A2-TP6	Note (3) Press ϕLOCK	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP13	Note (3) Press ϕLOCK	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP11	Note (3) Press ϕLOCK	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP14	Note (3) Press ϕLOCK	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP12	Note (3) Press ϕLOCK	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP15	Note (3) Press ϕLOCK	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP16	Note (3) Press ϕLOCK	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP17	Note (3) Press ϕLOCK	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	

Table 5-10. Test Point Measurements (Continued)

Phase Lock Sequence (continued)			
Test Point	Conditions	Comments	Measurement
A2-TP18	Note (3) Press ϕ LOCK	Logic 1 $\geq$ 3 volts Logic 0 $\leq$ 0.7 volt	

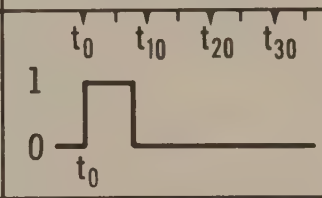
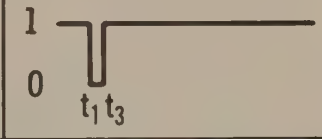
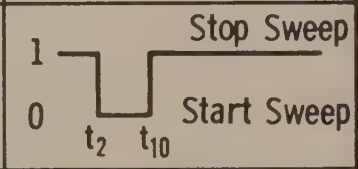
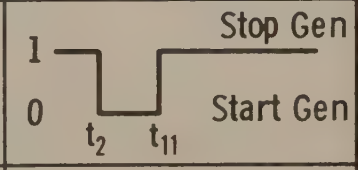
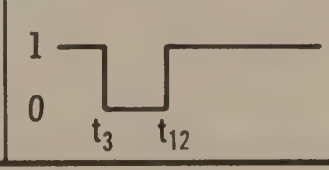
SWEEP TRIGGER SEQUENCE			
Test Point	Conditions	Comments	Measurement
A2-TP7	Note (3) Press SWEEP TRIG	Logic 1 $\geq$ 3 volts Logic 0 $\leq$ 0.7 volt	
A2-TP8 and A2-TP19	Note (3) Press SWEEP TRIG	Logic 1 $\geq$ 3 volts Logic 0 $\leq$ 0.7 volt	
A2-TP20	Note (3) Press SWEEP TRIG	Logic 1 $\geq$ 3 volts Logic 0 $\leq$ 0.7 volt	
A2-TP9	Note (3) Press SWEEP TRIG	Logic 1 $\geq$ 3 volts Logic 0 $\leq$ 0.7 volt	
A2-TP24	Note (3) Press SWEEP TRIG	Logic 1 $\geq$ 3 volts Logic 0 $\leq$ 0.7 volt	

Table 5-10. Test Point Measurements (Continued)

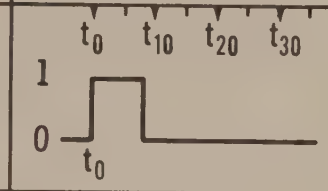
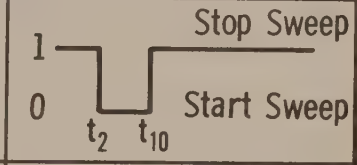
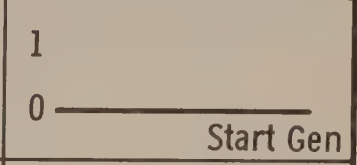
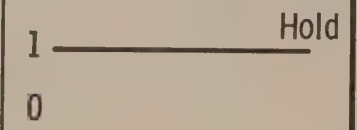
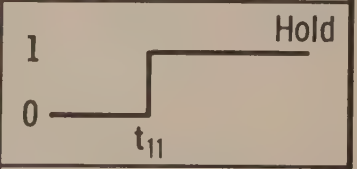
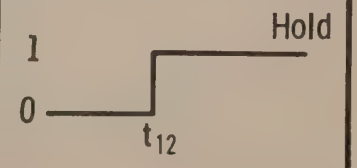
SWEEP SHIFT SEQUENCE			
Test Point	Conditions	Comments	Measurement
A2-TP7	Note (3) Press SWEEP SHIFT	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP8 and A2-TP19	Note (3) Press RESET (resets logic)	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP20	Note (3) Press SWEEP SHIFT	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP9	Note (3) Press SWEEP SHIFT	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP21	Note (3) Press SWEEP SHIFT	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP22	Note (3) Press SWEEP SHIFT	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	
A2-TP23	Note (3) Press SWEEP SHIFT	Logic 1 ≥ 3 volts Logic 0 ≤ 0.7 volt	

Table 5-10. Test Point Measurements (Continued)

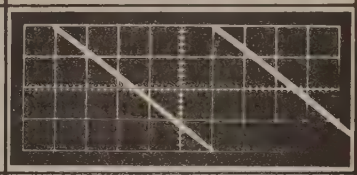
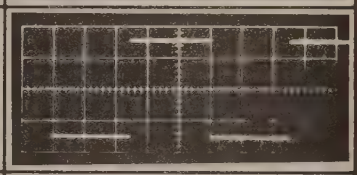
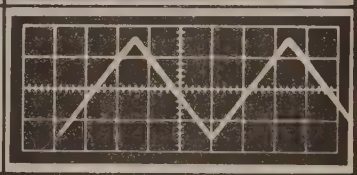
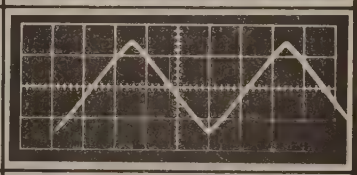
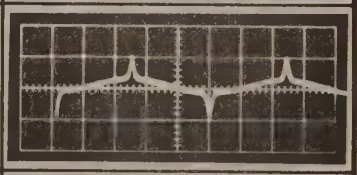
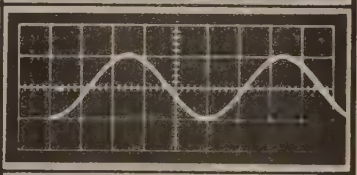
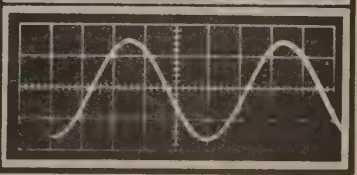
Test Point	Conditions	Comments	Measurement
A2-TP25	Note (1) Press SWEEP CONT	H = 0.2 ms/cm V = 1 v/cm -2 Volt level	
A2-TP26 (Sweep Amplifier Output)	Note (1) Press SWEEP CONT	H = 0.2 ms/cm V = 1 v/cm +2 Volt level	
A2-TP27 (Squarewave Output)	Note (1)	H = 0.2 ms/cm V = 2 v/cm	
A2-TP28 (Triangle Input)	Note (1)	H = 0.2 ms/cm V = 2 v/cm	
A2-TP29 (Sine Shaper Input)	Note (1)	H = 0.2 ms/cm V = 2 v/cm	
A2-TP30 (Sine Shaper)	Note (1)	H = 0.2 ms/cm V = 0.5 v/cm	
A2-TP31 (Sine Shaping)	Note (1)	H = 0.2 ms/cm V = 2 v/cm	
A2-TP32 (Sine Shaper Output)	Note (1)	H = 0.2 ms/cm V = 2 v/cm	

Table 5-10. Test Point Measurements (Continued)

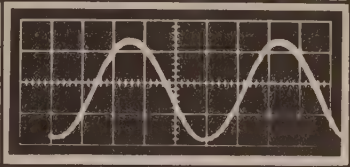
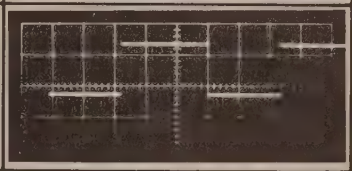
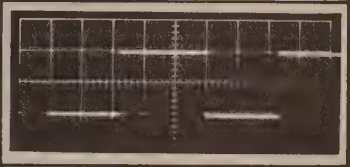
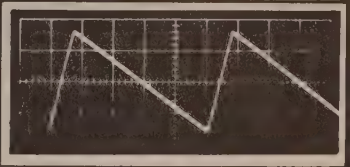
Conditions	Conditions	Comments	Measurement
A2-TP32 (Sine Shaper Output)	Note (2)	H = 0.2 μs/cm V = 2 v/cm	
A2-TP33 (Comparator Output)	Note (1) WAVEFORM ⎍ VAR PULSE control at center	H = 0.2 ms/cm V = 2 v/cm	
A2-TP34 (Pulse Width Output)	Note (1) WAVEFORM ⎍ VAR PULSE control at center	H = 0.2 ms/cm V = 5 v/cm	
A2-TP35 (Output Summing Amplifier Output)	Note (1) WAVEFORM ⩘	H = 0.2 ms/cm V = 2 v/cm	
A3-TP1 (+24 Volt Supply		Read dc	+24 volts
A3-TP2 (-24 Volt Supply)		Read dc	-24 volts
A3-TP3 (+12 Volt Supply)		Read dc	+12 volts
A3-TP4 (GND)			0 volts

Table 5-10. Test Point Measurements (Continued)

Test Point	Conditions	Comments	Measurement
A3-TP5 (-12 Volt Supply)		Read dc	-12 volts
A3-TP6 (+5 Volt Supply)		Read dc	+5 volts
A3-TP7 (-5 Volt Supply)		Read dc	-5 volts

NOTES:

(1) See conditions specified in paragraph 5-5h

(2) See conditions specified in paragraph 5-5h except set MULTIPLIER = 100K
Frequency = 1 MHz

(3) In addition to specified conditions in paragraph 5-5h, connect a 5 Vpp, 1 KHz sine wave at the TRIGGER SYNC terminal and set the PHASE and TRIGGER LEVEL controls at center of rotation

Section VI
REPLACEABLE PARTS

6-1. INTRODUCTION

This section contains information for identifying and ordering replacement parts. Replacement parts may be ordered from Interstate Electronics Corporation. Be certain that the order or inquiry identifies the part by description and part number.

Table 6-1 is a listing of all manufacturers supplying parts used in the function generator. Manufacturers are listed in numerical order by their respective code symbols.

6-2. PARTS LIST TABLES

Tables 6-2 through 6-5 list all electrical and electronic parts in alphanumeric order by reference designators and provide the following information for each part, where applicable: (a) value, (b) description, (c) total quantity used in the instrument (listed the first time the part number appears), (d) IEC part number, (e) manufacturer's code symbol, and (f) original manufacturer's part number. Mechanical parts are listed at the end of each table.

TABLE 6-1. LIST OF MANUFACTURERS

Code	Manufacturer
00287	CEM Co. Inc., Danielson, Connecticut
00779	AMP Inc., Harrisburg, Pennsylvania
00853	Sangamo Electric Co., S. Carolina Division, Pickens, South Carolina
01121	Allen-Bradley Co., Milwaukee, Wisconsin
01295	Texas Instruments Inc., Semiconductor-Components Division, Dallas, Texas
02114	Ferroxcube Corp., Of America, Saugerties, New York
02615	Nylok Corp., Paramus, New Jersey
02660	Amphenol Connector Division, Chicago, Illinois
02735	RCA Solid State and Receiving Tube Division, Somerville, New Jersey
03508	GE Co., Semi-Conductor Products Dept., Syracuse, New York
03877	Transitron Electronic Corporation, Wakefield, Massachusetts
03879	Akron Controller and Motor Inc., Akron, Ohio
04552	Emerson and Cuming Inc., Canton, Massachusetts
04713	Motorola Semiconductor Products Inc., Phoenix, Arizona
05820	Wakefield Engineering Inc., Wakefield, Massachusetts

Table 6-1. List of Manufacturers (Continued)

Code	Manufacturer
06540	Amaton Electronic Hardware Co. inc., New Rochelle, New York
06915	Richco Plastic Co., Chicago, Illinois
07263	Fairchild Camera and Inst. Corp., Mountain View, California
07421	Interstate Electronics Corp., Anaheim, California
07933	Raytheon Co., Lexington, Massachusetts
12324	Stake Fastener Co., South El Monte, California
13740	Kanarr Corp., Kingston, Pennsylvania
28480	Hewlett-Packard Co., Palo Alto, California
28520	Heyman Mfg. Co., Kenilworth, New Jersey
49956	Raytheon Co., Lexington, Massachusetts
56289	Sprague Electric Co., North Adams, Massachusetts
56878	Standard Pressed Steel, Unbrako Division, Jerkintown, Pennsylvania
70903	Belden Mfg. Co., Chicago, Illinois
71450	CTS Corp., Elkhart, Indiana
71785	Cinch Mfg. Co. and Howard B. Jones Div., Chicago, Illinois
72136	Electric Motive Mfg. Co. Inc., Willimantic, Connecticut
74970	E. F. Johnson Co., Waseca, Minnesota
75042	I R C Inc., Philadelphia, Pennsylvania
75915	Littelfuse Inc., Des Plaines, Illinois
76381	Minnesota Mining and Manufacturing Co., St. Paul, Minnesota
76493	J. W. Miller Co., Los Angeles, California
77969	Rubbercraft Corp. of Calif. Ltd., Torrance, California
78189	Shakeproof Division of Illinois Tool Works, Elgin, Illinois
80294	Bourns Inc., Riverside, California
82389	Switchcraft, Inc., Chicago, Illinois
83330	Herman H. Smith Inc., Brooklyn, New York
84171	ARCO Electronics Inc., Great Neck, New York
84411	TRW Capacitor Division, Ogallala, Nebrasks
86928	Seastrom Mfg. Co. Inc., Glendale, California
90201	Mallory Capacitor Co., Indianapolis, Indiana
93332	Sylvania Electric Products Inc., Semiconductor Division, Woburn, Massachusetts
95987	Weckesser Co., Chicago, Illinois
97979	Reon Resistor Corp., Yonkers, New York
98978	International Electronic Research Corp., Burbank, California
61637	Union Carbide Corporation, New York, New York

TABLE 6-2. TOP ASSEMBLY PARTS LIST

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
		Function Generator, Model F55	1	P00334000-4	07421	
		Function Generator, Model F55 (for Rack Mount)	1	P00334000-8	07421	
		Function Generator, Model F54	1	P00334000-3	07421	
		Function Generator, Model F54 (for Rack Mount)	1	P00334000-7	07421	
A1		Main Board Assembly, F55	1	P00334100-4	07421	
A1		Main Board Assembly, F54	1	P00334100-3	07421	
A2		Auxiliary Board Assembly, F55	1	P00334200-4	07421	
A2		Auxiliary Board Assembly, F54	1	P00334200-3	07421	
A3		Power Supply Board Assembly	1	P00334300-1	07421	
		Power Supply Board Assembly (for Rack Mount)	1	P00334300-2	07421	
		Package Assembly	1	P00332000-2	07421	
		Package Assembly (for Rack Mount)	1	P00332000-4	07421	
		Front Panel, F55	1	P00334040	07421	
		Front Panel, F54	1	P00334041	07421	
		Rear Panel	1	P00334046	07421	
		Knob Assembly, Frequency	1	P00333146	07421	
		Knob, Frequency Vernier	1	P00333024-9	07421	
		Knob, Sweep Limit	1	P00333142	07421	
		Knobs, Wave Form and Var Pulse With Sweep	1	P00333024-3	07421	
		Knobs, Sweeps/Sec and Vernier	1	P00333024-4	07421	
		Knob, Multiplier	1	P00333024-6	07421	
		Knobs, Attenuator and Output Adjust	1	P00333024-5	07421	
		Knobs, Phase and Trigger Level	1	P00333024-10	07421	
		Knobs, Offset and Adjust	1	P00333024-1	07421	
		Switch, Mode, F55	1	P00334030	07421	
		Switch, Mode, F54	1	P00334032	07421	
		Switch, Power	1	P00334031	07421	
		Cursor	1	P00333041	07421	
		Stand Off, Hinged	3	P00333321	07421	
		Name Plate	1	468-003-005	07421	
		Screw, Thread Cutting, Pan Head, Phillips Recessed	7		78189	Type I #4-40 x 1/4 LG
		Jumper, Nickel Plated	1		86928	5006-10
		Harness Wrap, Natural, 6"	1		06915	XRX-1/4
		Decal	1	P00334038	07421	
		Screw, Flat Head, 6-32 x 3/8 LG	2		02615	M39AS632R6C
		Screw, Pan Head, 6-32 x 3/8 LG	2		02615	M37AS632R6C
		Screw, Pan Head, Cross Recessed	4		12324	#4-4 x 1/4 LG

TABLE 6-3. MAIN BOARD (A1) PARTS LIST

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
A1		P.C. Board Assy, Main Generator	Ref	P00334100-4	07421	
R1	250Ω	R: Variable 1/4 Watt ±20%	2		97979	CLP-250-M
R2	10Ω	R: Metal Glaze 1/2 Watt ±5%	1		75042	RG20-100-J
R3	1K	Potentiometer, Freq	1		80294	34385-491-102
R4	2.5K	R: Variable 1/4 Watt ±20%	3		97979	CLP-2.5K-M
R5	1K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1001-F
R6	2.5K	R: Variable 1/4 Watt ±20%			97979	CLP-2.5K-M
R7	11.3K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1132-F
R8	4.75K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-4751-F
R9	12.4K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1242-F
R10	20K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-2202-F
R11	12.4K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1242-F
R12	1.8K	R: Metal Glaze 1/2 Watt ±5%	2		75042	RG20-182-J
R13	910Ω	R: Metal Glaze 1/4 Watt ±5%	4		75042	RG1/4-911-J
R14	4.7K	R: Metal Glaze 1/4 Watt ±5%	5		75042	RG1/4-472-J
R15	750Ω	R: Metal Glaze 1/4 Watt ±5%	6		75042	RG1/4-751-J
R16	330K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-334-J
R17	1.5K	R: Metal Glaze 1/4 Watt ±5%	9		75042	RG1/4-152-J
R18	50K	R: Variable 1/4 Watt ±20%	5		97979	CLP-50K-M
R19-R20	12.1K	R: Metal Film 1/4 Watt ±0.1%	2		75042	CEA-TO-1212-B
R21	1.8K	R: Metal Glaze 1/2 Watt ±5%			75042	RG20-182-J
R22	750Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-751-J
R23	1.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-152-J
R24	910Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-911-J
R25	1K	R: Metal Film 1/4 Watt ±1%	4		75042	CEA-TO-1001-F
R26	2.05K	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-2051-F
R27	10K	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-1002-F
R28	500Ω	R: Variable 1/4 Watt ±20%	5		97979	CLP-500-M
R29	10K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-1002-F
R30	1K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-1001-F
R31	2.05K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-2051-F
R32-R35	1M	R: Metal Film 1/2 Watt ±0.25%	10		75042	CCA-TO-1004-C
R36	332K	R: Metal Film 1/4 Watt ±0.25%	2		75042	CEA-TO-3323-C
R37	115K	R: Metal Film 1/4 Watt ±0.25%	3		75042	CEA-TO-1153-C
R38	33.2K	R: Metal Film 1/4 Watt ±0.25%	2		75042	CEA-TO-3323-C
R39	6.65K	R: Metal Film 1/4 Watt ±0.25%	2		75042	CEA-TO-6651-C
R40	1.33K	R: Metal Film 1/4 Watt ±0.25%	2		75042	CEA-TO-1331-C
R41-R44	1M	R: Metal Film 1/2 Watt ±0.25%			75042	CCA-TO-1004-C
R45	332K	R: Metal Film 1/4 Watt ±0.25%			75042	CEA-TO-3323-C
R46	115K	R: Metal Film 1/4 Watt ±0.25%			75042	CEA-TO-1153-C
R47	33.2K	R: Metal Film 1/4 Watt ±0.25%			75042	CEA-TO-3322-C
R48	6.65K	R: Metal Film 1/4 Watt ±0.25%			75042	CEA-TO-6651-C
R49	1.33K	R: Metal Film 1/4 Watt ±0.25%			75042	CEA-TO-1331-C
R50	115K	R: Metal Film 1/4 Watt ±0.25%			75042	CEA-TO-1153-C
R51	76.8K	R: Metal Film 1/4 Watt ±0.25%	1		75042	CEA-TO-7682-C
R52	10Ω	R: Metal Glaze 1/4 Watt ±5%	6		75042	RG1/4-100-J

Table 6-3. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
R53	665K	R: Metal Film 1/2 Watt ±0.25%	1		75042	CCA-TO-6653-C
R54	210K	R: Metal Film 1/4 Watt ±0.25%	1		75042	CEA-TO-2103-C
R55	23.2K	R: Metal Film 1/4 Watt ±0.25%	1		75042	CEA-TO-2322-C
R56	4.64K	R: Metal Film 1/4 Watt ±0.25%	1		75042	CEA-TO-4641-C
R57	931Ω	R: Metal Film 1/4 Watt ±0.25%	1		75042	CEA-TO-9310-C
R58	1M	R: Metal Film 1/2 Watt ±0.25%			75042	CCA-TO-1004-C
R59	121K	R: Metal Film 1/4 Watt ±0.25%	1		75042	CEA-TO-1213-C
R60	1M	R: Metal Film 1/2 Watt ±0.25%			75042	CCA-TO-1004-C
R61	432K	R: Metal Film 1/4 Watt ±0.25%	1		75042	CEA-TO-4323-C
R62	143K	R: Metal Film 1/4 Watt ±0.25%	1		75042	CEA-TO-1433-C
R63	14.3K	R: Metal Film 1/4 Watt ±0.25%	1		75042	CEA-TO-1432-C
R64	2.87K	R: Metal Film 1/4 Watt ±0.25%	1		75042	CEA-TO-2371-C
R65	576Ω	R: Metal Film 1/2 Watt ±0.25%	1		75042	CCA-TO-5760-C
R66	2K	R: Metal Glaze 1/4 Watt ±5%	8		75042	RG1/4-202-J
R67	240K	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-244-J
R68	10K	R: Variable 1/4 Watt ±20%	6		97979	CLP-10K-M
R69-R70	100K	R: Metal Glaze 1/4 Watt ±5%	9		75052	RG1/4-104-J
R71	1.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-152-J
R72	470Ω	R: Metal Glaze 1/4 Watt ±5%	4		75042	RG1/4-471-J
R73	10Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-100-J
R74	100K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-104-J
R75	10K	R: Variable 1/4 Watt ±20%			97979	CLP-10K-M
R76	240K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-244-J
R77	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R78-R79	62K	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-623-J
R80	1.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-152-J
R81	470Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-471-J
R82	10Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-100-J
R83	100K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-104-J
R84	51Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-510-J
R85	30K	R: Metal Glaze 1/4 Watt ±5%	4		75042	RG1/4-303-J
R86	340Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-3400-F
R87	432Ω	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-4320-F
R88	3.32K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-3321-F
R89	1.1K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1101-F
R90	30K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-303-J
R91	75Ω	R: Metal Film 1/4 Watt ±1%	4		75042	CEA-TO-75R0-F
R92	357Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-3570-F
R93	1K	R: Metal Glaze 1/4 Watt ±5%	10		75042	RG1/4-102-J
R94	270Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-271-J
R95	51Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-510-J
R96-R97	5.6Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-5R6-J
R98	22Ω	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-220-J
R99	Unassigned					
R100-R101	100Ω	R: Metal Glaze 1/4 Watt ±5%	5		75042	RG1/4-101-J
R102	49.9Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-49R9-F

Table 6-3. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
R103	1K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-1001-F
R104	Unassigned					
R105	1.96K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-1961-F
R106	340Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-3400-F
R107	432Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-4320-F
R108	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R109	39K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-393-J
R110	10K	R: Variable 1/4 Watt ±20%			97979	CLP-10K-M
R111	100Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-101-J
R112	10Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-100-J
R113	22Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-220-J
R114	500Ω	R: Variable 1/4 Watt ±20%			97979	CLP-500-M
R115	2K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-2001-F
R116	49.9Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-49R9-F
R117	2.5K	Potentiometer, Var Pulse	1	P00334025-2	07421	
R118-R121	Unassigned					
R122	100Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1000-F
R123	Unassigned					
R124	500Ω	Potentiometer, Output Adjust	1	P00334021	07421	
R125	44.2Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-44R2-F
R126	150Ω	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-151-J
R127	240Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-241-J
R128	2.2K	R: Metal Glaze 1 Watt ±5%	3		75042	RG1/4-222-J
R129	62Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-620-J
R130	4.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-472-J
R131	62Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-620-J
R132	2.2K	R: Metal Glaze 1 Watt ±5%			75042	RG1/4-222-J
R133	270Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-271-J
R134	910Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-911-J
R135	330Ω	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-331-J
R136	6.2K	R: Metal Glaze 1/4 Watt ±5%	5		75042	RG1/4-622-J
R137	4.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-472-J
R138	6.2K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-622-J
R139	330Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-331-J
R140	910Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-911-J
R141-R142	110Ω	R: Metal Glaze 1/4 Watt ±5%	5		75042	RG1/4-111-J
R143	82Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-820-J
R144	22Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-220-J
R145	806Ω	R: Metal Film 1/4 Watt±1%	1		75042	CEA-TO-8060-F
R146	249Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-2490-F
R147	12K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-123-J
R148	50K	R: Variable 1/4 Watt ±20%			97979	CLP-50K-M
R149-R150	110Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-111-J
R151	11Ω	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-110-J
R152	250Ω	R: Variable 1/4 Watt ±20%	1		97979	CLP-250-M
R153-R154	39Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-390-J

Table 6-3. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
R155	22Ω	R: Metal Glaze 1 Watt ±5%	2		75042	RG32-220-J
R156-R157	5.6Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-5R6-J
R158	22Ω	R: Metal Glaze 1 Watt ±5%			75042	RG32-220-J
R159-R160	100Ω	R: Metal Film 1 Watt ±0.1%	2		75042	CAA-TO-100R0-B
R161-R162	96.25Ω	R: Metal Film 1/4 Watt ±0.1%	2		75042	CEA-TO-96R25-B
R163	71.16Ω	R: Metal Film 1/4 Watt ±0.1%			75042	CEA-TO-71R16-B
R164	4.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-472-J
R165	1.1K	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-112-J
R166	5.1K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-512-J
R167	7.5K	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-752-J
R168	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R169	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R170	2K	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-202-J
R171	5K	R: Variable 1/4 Watt ±20%			97979	CLP-5K-M
R172	10K	R: Metal Glaze 1/4 Watt ±5%	16		75042	RG1/4-103-J
R173	1K	R: Metal Glaze 1/2 Watt ±5%			75042	RG20-102-J
R174	510Ω	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-511-J
R175	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R176	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R177	510Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-511-J
R178	2.5K	Potentiometer, Phase	1	P00334026	07421	
R179	390K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-394-J
R180	68K	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-683-J
R181	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J
R182	7.5K	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-752-J
R183	68K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-683-J
R184	510Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-511-J
R185	1.8K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-182-J
R186	1.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-152-J
R187	750Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-751-J
R188	5.1K	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-512-J
R189	1K	R: Variable 1/4 Watt ±20%	1		97979	CLP-1K-M
R190	1.8K	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-182-J
R191	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R192	2.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-272-J
R193	390Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-391-J
R194	2.5K	Potentiometer, Vernier	1	P00334024	07421	
R195	215Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-2150-F
R196	30.1K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-3012-F
R197-R198	Unassigned					
R199-R200	1M	R: Metal Film 1/2 Watt ±1%	2		75042	CCA-TO-1004-F
R201-R204	Unassigned					
R205	301K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-3013-F
R206	1M	R: Metal Film 1/2 Watt ±1%	2		75042	CCA-TO-1004-F
R207	25K	R: Variable 1/4 Watt ±20%	3		97979	CLP-25K-M
R208	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J

Table 6-3. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
R209-R210	Unassigned					
R211	500Ω	R: Variable 1/4 Watt ±20%			97979	CLP-500-M
R212-R213	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J
R214	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R215-R216	30K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-303-J
R217	200Ω	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-201-J
R218	3K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-302-J
R219	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R220	2.49K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-2491-F
R221	750Ω	R: Metal Film 1/2 Watt ±1%			75042	CEA-TO-7500-F
R222	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R223	5K	R: Variable 1/4 Watt ±20%	3		97979	CLP-5K-M
R224	3K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-302-J
R225-R226	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R227	6.2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-622-J
R228	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R229	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J
R230	7.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-752-J
R231	1.2K	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-122-J
R232	100K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-104-J
R233	33K	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-333-J
R234-R235	124Ω	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-1240-F
R236	84.5Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-84R5-F
R237	33K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-333-J
R238	4.32K	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-4321-F
R239	500Ω	R: Variable 1/4 Watt ±20%			97979	CLP-500-M
R240	665Ω	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-6650-F
R241	120Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-121-J
R242	11K	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-1102-F
R243	1.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-152-J
R244	Unassigned					
R245	7.5K	R: Metal Film 1/4 Watt ±1%	4		75042	CEA-TO-7501-F
R246	15K	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-1502-F
R247	25K	R: Variable 1/4 Watt ±20%			97979	CLP-25K-M
R248	2.7K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-272-J
R249	22K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-223-J
R250	39K	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-393-J
R251	10K	R: Variable 1/4 Watt ±20%			97979	CLP-10K-M
R252	120Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-121-J
R253	750Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-751-J
R254	6.2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-622-J
R255	7.5K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-7501-F
R256	1.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-152-J
R257	Unassigned					
R258	5K	R: Variable 1/4 Watt ±20%			97979	CLP-5K-M
R259	470Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-471-J

Table 6-3. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
R260	4.32K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-4321-F
R261	500Ω	R: Variable 1/4 Watt ±20%			97979	CLP-500-M
R262	665Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-6650-F
R263	Unassigned					
R264	11K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-1102-F
R265	1.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-152-J
R266	Unassigned					
R267	7.5K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-7501-F
R268	15K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-1502-F
R269	25K	R: Variable 1/4 Watt ±20%			97979	CLP-25K-M
R270	22K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-223-J
R271	500Ω	Potentiometer, Sweep Limit	1	P00334027	07421	
R272	20K	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-203-J
R273	150Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-1500-F
R274	100Ω	R: Variable 1/4 Watt ±20%			97979	CLP-100-M
R275	75Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-75R0-F
R276	20K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-203-J
R277	Unassigned					
R278	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J
R279	20K	R: Metal Glaze 1/2 Watt ±5%	2		75042	RG20-203-J
R280	100K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-104-J
R281	Unassigned					
R282	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J
R283	20K	R: Metal Glaze 1/2 Watt ±5%			75042	RG20-203-J
R284	866Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-8660-F
R285	47Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-470-J
R286-R287	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J
R288	1.8K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-182-J
R289	1.2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-122-J
R290	825Ω	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-8250-F
R291	560Ω	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-561-J
R292	240Ω	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-241-J
R293	100K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-104-J
R294	200Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-201-J
R295	4.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-472-J
R296	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J
R297	4.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-472-J
R298	510Ω	R: Metal Glaze 1 Watt ±5%			75042	RG32-511-J
R299-R300	1.1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-112-J
R301	6.8K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-682-J
R302	56Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-560-J
R303-R304	3.3Ω	R: Carbon 1/4 Watt ±5%	2		75042	RG07GF3R3-J
R305	1.5K	R: Metal Glaze 1 Watt ±5%	1		75042	RG32-152-J
R306	56Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-560-J
R307	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J
R308	825Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-8250-F

Table 6-3. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
R309	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J
R310	1.8K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-182-J
R311	1.5K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1501-F
R312	47Ω	R: Metal Glaze 1/4 Watt±5%			75042	RG1/4-470-J
R313	1.6K	R: Metal Glaze 1 Watt ±5%			75042	RG32-162-J
R314	715Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-7150-F
R315	2.5K	Potentiometer, Trigger Level	1	P00334026	07421	
R316	240Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-241-J
R317	3.3K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-332-J
R318	2.2K	R: Metal Glaze 1 Watt ±5%			75042	RG1/4-222-J
R319-R320	75Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-750-J
R321	1.47K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-1471-F
R322	39K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-393-J
R323	10K	R: Variable 1/4 Watt ±20%			97979	CLP-10K-M
R324	750Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-751-J
R325	6.2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-622-J
R326	7.5K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-7501-F
R327	1.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-152-J
R328	470Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-471-J
R329	2.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-272-J
R330-R331	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J
R332	3M	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-305-J
R333	200Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-201-J
R334	3Ω	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-3R0-J
R335	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R336	2.49K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-2491-F
R337	390Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-391-J
R338	130Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-131-J
R339	Unassigned					
R340	449Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-4990-F
R341	1K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-1001-F
R342	Unassigned					
R343	130Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-131-J
R344	240Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-241-J
R345	10.20Ω	R: Metal Film 1/4 Watt ±0.1%	1		75042	CEA-TO-10R20-B
R346-R347	40.91Ω	R: Metal Film 1/4 Watt ±0.1%	2		75042	CEA-TO-40R91-B
R348	71.63Ω	R: Metal Film 1/4 Watt ±0.1%	1		75042	CEA-TO-71R63-B
R349	156.1Ω	R: Metal Film 1/4 Watt ±0.1%	1		75042	CEA-TO-156R1-B
R350	40.03Ω	R: Metal Film 1/4 Watt ±0.1%	1		75042	CEA-TO-40R03-B
R351	10.53Ω	R: Metal Film 1/4 Watt ±0.1%	1		75042	CEA-TO-10R53-B
R352	866Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-8660-F
R353	78.7K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-7872-F
R354	390Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-391-J
R355	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R356	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R357	100Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-101-J

Table 6-3. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
R358-R359	100K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-104-J
R360	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R361	100K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-104-J
R362	30K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-303-J
R363	2.4K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-242-J
R364	4.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-472-J
R365	78.7K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-7872-F
R366	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R367	50Ω	R: Variable 1/4 Watt ±20%	1		97979	CLP-50-M
R368	2.5K	R: Variable 1/4 Watt ±20%			97979	CLP-2.5K-M
R369	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R370	1.2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-122-J
R371-R372	100Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-101-J
R373	620Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-621-J
R374	Select	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-(Select)
R375	12.4K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-1242-F
R376	1.8K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-182-J
C1	0.1µf	C: Ceramic 100 volts +80% -20%	55		56289	33C41C
C2-C3	15µf	C: Electrolytic 50 volts +75% -10%	4		56289	30D156G050CB2
C4-C7	20µf	C: Electrolytic 16 volts +75% -10%	6		56289	30D206G016BB2
C8-C14	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C15	500pf	C: Ceramic 1000 volts ±10%	5		56289	C016A102F501K
C16	20pf	C: Ceramic 1000 volts ±10%	4		56289	C030A102F200K
C17-C18	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C19	500pf	C: Ceramic 1000 volts ±10%			56289	C016A102F501K
C20	20pf	C: Ceramic 1000 volts ±10%			56289	C030A102F200K
C21	100pf	C: Ceramic 1000 volts ±10%	2		56289	C028A102E101K
C22	3.3pf	C: Ceramic 1000 volts ±0.5pf	4		56289	C030A102E3R3D
C23	20µf	C: Electrolytic 16 volts +75% -10%			56289	30D206G016BB2
C24	200pf	C: Mica 500 volts ±10%	5		00853	CM05-ED-201K
C25	100pf	C: Ceramic 1000 volts ±10%			56289	C028A102E101K
C26	3.3pf	C: Ceramic 1000 volts ±0.5pf			56289	C030A102E3R3D
C27	20µf	C: Electrolytic 16 volts +75% -10%			56289	30D206G016BB2
C28	200pf	C: Mica 500 volts ±10%			00853	CM05-ED-201K
C29	10µf	C: Mylar 100 volts ±5%	2		84411	X663F-10651W2
C30	0.1µf	C: Polyester 50 volts ±2%	2		56289	414P-1042R5
C31	750pf	C: Mica 300 volts ±2%	1		00853	CM05-ED-751G
C32	220pf	C: Mica 300 volts ±2%	1		00853	CM05-ED-221G
C33	Select	C: Mica 500 volts ±5%	1		00853	CM05-ED-(Select)
C34	2.4-24.5pf	C: Variable Air Dielectric	4		74970	189-509-5
C35	Unassigned					
C36	0.01µf	C: Ceramic 100 volts ±20%	7		56289	C023A101F103M
C37	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C38	2.4-24.5pf	C: Variable Air Dielectric			74970	189-509-5
C39-C40	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C41	Select	C: Mica (select)			04062	DM15-(Select)

Table 6-3. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
C42-C43	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C44-C45	0.002µf	C: Ceramic 1000 volts ±20%	4		56289	C016A102J202M
C46-C47	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C48	0.002µf	C: Ceramic 1000 volts ±20%			56289	C016A102J202M
C49-C50	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C51	0.002µf	C: Ceramic 1000 volts ±20%			56289	C016A102J202M
C52-C53	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C54	Unassigned					
C55	20µf	C: Electrolytic 20 volts +50% -10%	1		90201	MTV20T20NPCB
C56	2µf	C: Electrolytic 20 volts +50% -10%	1		90201	MTV2T20NPCB
C57	1µf	C: Electrolytic 20 volts +50% -10%	2		90201	MTV001T20NPCB
C58	0.1µf	C: Polyester 80 volts ±10%	2		56289	192P-1049R8
C59	0.01µf	C: Ceramic 100 volts ±20%			56289	C023A101F103M
C60	0.001µf	C: Ceramic 1000 volts ±20%			56289	C016A102G102M
C61	200pf	C: Mica 200 volts ±10%	3		00853	CM05-ED-201K
C62	0.0047µf	C: Ceramic 25 volts ±20%	3		56289	C069A250C472M
C63	10µf	C: Electrolytic 20 volts +50% -10%			90201	MTV010T20NPCB
C64	1µf	C: Electrolytic 20 volts +50% -10%			90201	MTV001T20NPCB
C65	0.1µf	C: Polyester 80 volts ±10%			56289	129P-1049R8
C66	0.01µf	C: Ceramic 100 volts ±20%			56289	C023A101F103M
C67	1500pf	C: Mica 500 volts ±10%	1		84171	CM06-ED-152K
C68	560pf	C: Mica 500 volts ±10%	1		00853	CM05-ED-561K
C69	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C70	1000pf	C: Mica 100 volts ±1%	1		84171	CM06-ED-102F
C71	0.1µf	C: Polyester 50 volts ±5%			56289	410P-1045R5
C72	10µf	C: Mylar 100 volts ±5%			84411	X663F-10651W2
C73	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C74	500pf	C: Ceramic 1000 volts ±10%			56289	C016A102F501K
C75-C77	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C78-C79	47pf	C: Mica 500 volts ±10%	2		00853	CM05-ED-470K
C80	820pf	C: Ceramic 1000 volts ±10%	1		56289	C016K102F821K
C81	50pf	C: Mica 500 volts ±10%	1		00853	CM05-ED-500K
C82-C85	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C86	20pf	C: Ceramic 1000 volts ±10%			56289	C030A102F200K
C87	75pf	C: Mica 500 volts ±10%	1		00853	CM05-ED-750K
C88	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C89	200pf	C: Mica 200 volts ±10%			00853	CM05-ED-201K
C90	0.0047µf	C: Ceramic 25 volts ±20%			56289	C069A250C472M
C91	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C92	20pf	C: Ceramic 1000 volts ±10%			56289	C030A102F200K
C93	500pf	C: Ceramic 1000 volts ±10%			56289	C016A102F501K
C94	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C95	10pf	C: Mica 500 volts ±10%			00853	CM05-ED-100K
C96	Unassigned					
C97	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C98	180pf	C: Mica 500 volts ±2%	1		00853	CM05-ED-181G

Table 6-3. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
C99	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C100	500pf	C: Ceramic 1000 volts ±10%			56289	C016A102F501K
C101-C105	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C106	5pf	C: Mica 500 volts ±0.5pf			00853	CM05-ED-050K
C107-C109	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C110	200pf	C: Mica 500 volts ±10%			00853	CM05-ED-201K
C111	0.0047µf	C: Ceramic 25 volts ±20%			56289	C069A250C472M
C112	2.4-24.5pf	C: Variable Air Dielectric			74970	189-509-5
C113	3.3pf	C: Ceramic 1000 volts ±0.5pf			56289	C030A102E3R3D
C114	Select	C: Mica 500 volts (select)	1		00853	CM05-(Select)
C115	1.8-16.7pf	C: Variable Air Dielectric			74970	189-506-5
C116	0.001µf	C: Ceramic 1000 volts ±20%			56289	C016A102G102M
C117	15µf	C: Electrolytic 50 volts +75% -10%			56289	30D156G050CB2
C118-C119	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C120	15µf	C: Electrolytic 50 volts +75% -10%			56289	30D156G050CB2
C121-C123	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C124	180pf	C: Mica 500 volts ±10%			00853	CM05-ED-181K
C125	0.01µf	C: Ceramic 100 volts ±20%			56289	C023A101F103M
C126-C129	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C130	0.01µf	C: Ceramic 100 volts ±20%			56289	C023A101F103M
C131	47pf	C: Mica 500 volts ±10%	1		00853	CM05-ED-470K
C132	0.01µf	C: Ceramic 100 volts ±20%			56289	C023A101F103M
C133	200pf	C: Mica 500 volts ±10%	1		00853	CM05-ED-201K
C134	160pf	C: Mica 500 volts ±2%	1		00853	CM05-ED-161G
C135	0.001µf	C: Ceramic 1000 volts ±20%			56289	C016A102G102M
C136	Select	C: Mica 500 volts ±10%			00853	CM05-ED-(Select)
C137	0.01µf	C: Ceramic 100 volts ±20%			56289	C023A101F103M
C138	270pf	C: Mica 500 volts ±10%			00853	CM05-ED-271K
C139	10pf	C: Mica 500 volts ±10%			00853	CM05-ED-100K
Q1-Q2		TSTR: Silicon PNP	9		04713	2N 3906
Q3-Q4		TSTR: Silicon NPN	19		04713	2N 3904
Q5-Q6		TSTR: Dual N Chan JFET	4	P00347201	61637	2N 3958
Q7		TSTR: P Chan JFET	1	P00347250	07421	UC400
Q8		TSTR: N Chan JFET	2	P00347202	07421	2N 4092
Q9		TSTR: Silicon PNP	1	P00347100	07421	
Q10		TSTR: Silicon NPN	1	P00347000	07421	
Q11		TSTR: Dual N Chan JFET		P00347201	61637	2N 3958
Q12		TSTR: Silicon PNP	5	P00347101	07421	
Q13		TSTR: Silicon PNP	5		02735	2N 5187
Q14-Q15		TSTR: Silicon PNP		P00347101	07421	
Q16		TSTR: Silicon NPN			02735	2N 5187
Q17-Q18		TSTR: Silicon NPN		P00347001	07421	
Q19-Q20		TSTR: Silicon NPN	3		07263	2N 3261
Q21		TSTR: Silicon PNP			04713	2N 3906
Q22-Q23		TSTR: Silicon NPN			04713	2N 3904
Q24		TSTR: Silicon NPN	1		07263	2N 2219A

Table 6-3. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
Q25		TSTR: Silicon PNP	1		07263	2N 2905A
Q26-Q27		TSTR: Silicon PNP			04713	2N 3906
Q28		TSTR: N Chan JFET		P00347203	07421	2N 4091
Q29		TSTR: Silicon PNP		P00347101	07421	
Q30	Unassigned					
Q31-Q34		TSTR: Silicon NPN			04713	2N 3904
Q35		TSTR: N Chan JFET	1	P00347203	07421	2N 4091
Q36		TSTR: Dual N Chan JFET		P00347201	61637	2N 3958
Q37-Q38		TSTR: Silicon PNP			04713	2N 3906
Q39		TSTR: Silicon PNP	5		07263	2N 4258
Q40		TSTR: Silicon NPN			02735	2N 5187
Q41	Unassigned					
Q42		TSTR: Silicon NPN			04713	2N 3904
Q43	Unassigned					
Q44		TSTR: Silicon PNP			07263	2N 4258
Q45-Q48	Unassigned					
Q49		TSTR: Silicon NPN			04713	2N 3904
Q50		TSTR: Silicon PNP			04713	2N 3906
Q51		TSTR: Silicon PNP		P00347103	07421	
Q52		TSTR: Silicon NPN			04713	2N 3904
Q53-Q54		TSTR: Silicon PNP		P00347103	07421	
Q55-Q56		TSTR: Silicon NPN			02735	2N 5187
Q57		TSTR: Silicon NPN			04713	2N 3904
Q58		TSTR: Silicon PNP			04713	2N 3906
Q59		TSTR: Silicon NPN			04713	2N 3904
Q60		TSTR: Silicon PNP			07263	2N 4258
Q61-Q62		TSTR: Silicon NPN			04713	2N 3904
Q63		TSTR: Silicon PNP			07263	2N 4258
Q64		TSTR: Silicon NPN			07263	2N 3261
Q65		TSTR: Silicon NPN	1		02735	RCA40235
CR1		Diode: Switching, Hot Carrier	7		38480	HP-5082-2811
CR2-CR3		Diode: Low Leakage	5		07263	FD 333
CR4		Diode: Switching, Hot Carrier			28480	HP-5082-2811
CR5		Diode: Low Leakage			07263	FD 333
CR6-CR7		Diode: Switching, Hot Carrier			28480	HP-5082-2811
CR8		Diode: Low Leakage			07263	FD 333
CR9	Select	Diode: Zener 400 mw ±5%	1		04713	(Select)
CR10-CR15		Diode: Silicon	43		03508	1N 914A
CR16	12.0v	Diode: Zener 400 mw ±5%	1		04713	1N 5242B
CR17-CR21		Diode: Silicon			03508	1N 914A
CR22		Diode: Low Leakage			07263	FD 333
CR23		Diode: Switching, Hot Carrier			28480	HP-5082-2811
CR24-CR32		Diode: Silicon			03508	1N 914A
CR33	6.2v	Diode: Zener 400 mw ±5%			04713	1N 5234B
CR34		Diode: Silicon			03508	1N 914A
CR35	Unassigned					

Table 6-3. Main Board (A1) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
CR36-CR37		Diode: Switching, Hot Carrier	2		28480	HP-5082-2816
CR38-CR39		Diode: Silicon			03508	1N 914A
CR40		Diode: Tunnel	2		03508	1N 3719
CR41		Diode: Silicon			03508	1N 914A
CR42	5.6v	Diode: Zener 400 mw ±5%	1		04713	1N 5232B
CR43		Diode: Silicon			03508	1N 914A
CR44	4.7v	Diode: Zener 400 mw ±5%	3		04713	1N 5230B
CR45		Diode: Silicon			03508	1N 914A
CR46-CR47	4.7v	Diode: Zener 400 mw ±5%			04713	1N 5230B
CR48-CR52		Diode: Silicon			03508	1N 914A
CR53	Unassigned					
CR54	3.9v	Diode: Zener 400 mw ±5%	1		04713	1N 5228B
CR55-CR57		Diode: Silicon			03508	1N 914A
CR58	3.0v	Diode: Zener 400 mw ±5%	1		04713	1N 5225B
CR59		Diode: Silicon			03508	1N 914A
CR60		Diode: Tunnel			03508	1N 3719
CR61-CR62		Diode: Switching, Hot Carrier			28480	HP-5082-2811
CR63-CR65		Diode: Silicon			03508	1N 914A
CR66	9.1v	Diode: Zener 400 mw ±5%	1		04713	1N 5239B
CR67-CR69		Diode: Silicon			03508	1N 914A
IC1-IC4		Integrated Circuit Amp (μA709C)	9		03877	TOA2709E
IC5		Integrated Circuit Array	1		02735	CA 3049
IC6		Integrated Circuit Amp (μA709C)			03877	TOA2709E
IC7		Integrated Circuit Amp (μA702C)	1		07933	RC702C
IC8		Integrated Circuit Comparator (μA710C)	1		03877	TDC2710E
IC9-IC11		Integrated Circuit Amp (μA709C)			03877	TOA2709E
IC12-IC13		Integrated Circuit Array	3		02735	CA 3018A
IC14		Integrated Circuit Amp (μA709C)			03877	TOA2709E
IC15		Integrated Circuit Array			02735	CA 3018A
S1		Switch, Multiplier	1	P00334020	07421	
S2		Switch, Waveform with Pot	1	P00334025	07421	
S3		Switch, Attenuator with Pot	1	P00334021	07421	
S4		Switch, Sweep/Sec with Pot	1	P00334024	07421	
		Wire, Kynar 2, 24 AWG	A/R	516-061-001	07421	
		Bead, Shielding	15		02114	K5001003B
TP1-TP36		Test Points	63		00779	61067-1
		Cable Assembly, 29 Pin	1	P00333600-2	07421	
		Cable Assembly, 19 Pin	1	P00333600-3	07421	
E49-E56, E58-E66, E73-E80		Test Points			00779	61067-1

TABLE 6-4. AUXILIARY BOARD (A2) PARTS LIST

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
A2		P.C. Board Ass'y, Auxiliary Generator	Ref	P00334200-4	07421	
R1-R2	249Ω	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-2490-F
R3	2.67K	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-2671-F
R4	2.5K	R: Variable ±20%	1	P00333023	07421	
R5	300Ω	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-301-J
R6-R7	250Ω	R: Variable 1/4 Watt ±20%	2		97979	CLP-250-M
R8	47K	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-473-J
R9	511Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-5110-F
R10	270Ω	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-271-J
R11	10K	R: Variable 1/4 Watt ±20%	3		97979	CLP-10K-M
R12	30Ω	R: Metal Glaze 1/4 Watt ±5%	4		75042	RG1/4-300-J
R13	1K	R: Metal Glaze 1/4 Watt ±5%	7		75042	RG1/4-102-J
R14	30Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-300-J
R15	1.2K	R: Metal Glaze 1/4 Watt ±5%	4		75042	RG1/4-122-J
R16	100Ω	R: Metal Glaze 1/4 Watt ±5%	10		75042	RG1/4-101-J
R17	1.2K	R: Metal Glaze 1 Watt ±5%	2		75042	RG32-122-J
R18	634Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-6340-F
R19	510Ω	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-511-J
R20	1.2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-122-J
R21	100Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-101-J
R22	390Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-391-J
R23	51Ω	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-510-J
R24-R25	15Ω	R: Metal Glaze 1/4 Watt ±5%	4		75042	RG1/4-150-J
R26	2.43K	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-2431-F
R27	619Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-6190-F
R28	2K	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-2001-F
R29	100Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-101-J
R30	470Ω	R: Metal Glaze 1/4 Watt ±5%	4		75042	RG1/4-471-J
R31	100Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-101-J
R32	20K	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-203-J
R33	3.01K	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-3011-F
R34	2K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-2001-F
R35	390Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-391-J
R36	1.8K	R: Metal Glaze 1/2 Watt ±5%	1		75042	RG20-182-J
R37	2.43K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-2431-F
R38	3.01K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-3011-F
R39	39Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-390-J
R40-R41	10Ω	R: Metal Glaze 1/4 Watt ±5%	7		75042	RG1/4-100-J
R42	39Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-390-J
R43	107Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1070-F
R44	200Ω	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-2000-F
R45	100Ω	R: Variable 1/4 Watt ±20%	2		97979	CLP-100-M
R46	10K	R: Metal Glaze 1/4 Watt ±5%	4		75042	RG1/4-103-J
R47-R48	5.1K	R: Metal Glaze 1/2 Watt ±5%	2		75042	RG20-512-J
R49	4.7K	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-472-J
R50	82K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-823-J

Table 6-4. Auxiliary Board (A2) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
R51	1.1K	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-112-J
R52	2.2K	R: Metal Glaze 1/4 Watt ±5%	9		75042	RG1/4-222-J
R53	2.7K	R: Metal Glaze 1/4 Watt ±5%	3		75042	RG1/4-272-J
R54-R59	2.2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-222-J
R60-R61	200Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-201-J
R62	2.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-272-J
R63	470Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-471-J
R64	47K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-473-J
R65	750Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-751-J
R66	2.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-272-J
R67-R69	100Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-101-J
R70-R71	2K	R: Metal Glaze 1/4 Watt ±5%	8		75042	RG1/4-202-J
R72	5.1K	R: Metal Glaze 1/4 Watt ±5%	4		75042	RG1/4-512-J
R73-R74	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R75-R76	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R77	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J
R78	5.1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-512-J
R79	20K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-203-J
R80	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J
R81	15K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-153-J
R82	10K	R: Variable 1/4 Watt ±20%			97979	CLP-10K-M
R83	10K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1002-F
R84	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R85	10Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-100-J
R86	10K	R: Variable 1/4 Watt ±20%			97979	CLP-10K-M
R87	9.09K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-9091-F
R88	25K	R: Variable 1/4 Watt ±20%	1		97979	CLP-2.5K-M
R89	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R90	5.1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-512-J
R91	62Ω	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-620-J
R92	5.1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-512-J
R93	10K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-103-J
R94	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R95	82.5Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-82R5-F
R96	100Ω	R: Variable 1/4 Watt ±20%			97979	CLP-100-M
R97	348Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-3480-F
R98	49.9Ω	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-49R9-F
R99	510Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-511-J
R100	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R101-R105	Unassigned					
R106	1.1K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-1101-F
R107-R108	2.21K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-2211-F
R109	1.1K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-1101-F
R110	47.5Ω	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-47R5-F
R111	Unassigned					
R112	50Ω	R: Variable 1/4 Watt ±20%			97979	CLP-50-M

Table 6-4. Auxiliary Board (A2) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
R113	124Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1240-F
R114	49.9Ω	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-49R9-F
R115	75Ω	R: Metal Film 1/4 Watt ±1%	2		75042	CEA-TO-75R0-F
R116	150Ω	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-151-J
R117-R118	4.7Ω	R: Carbon 1/4 Watt ±5%	2		75042	RC07GF-4R7-J
R119	22Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-220-J
R120	470Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-471-J
R121-R122	30Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-300-J
R123	470Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-471-J
R124-R125	10Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-100-J
R126	1.2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-122-J
R127	500Ω	R: Variable 1/4 Watt ±20%	4		97979	CLP-500-M
R128	620Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-621-J
R129	43Ω	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-430-J
R130	4.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-472-J
R131	Unassigned					
R132	7.5Ω	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-7R5-J
R133	22.1Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-22R1-F
R134	39.2Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-39R2-F
R135	47.5Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-47R5-F
R136	130Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1300-F
R137	182Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1820-F
R138	430Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-431-J
R139	100Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-101-J
R140	430Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-431-J
R141	1.2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-122-J
R142	500Ω	R: Variable 1/4 W tt ±20%			97979	CLP-500-M
R143	620Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-621-J
R144-R158	Unassigned					
R159	49.9Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-49R9-F
R160	75Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-75R0-F
R161	150Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1500-F
R162-R164	Unassigned					
R165	20K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-203-J
R166	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R167	750Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-751-J
R168	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R169	Unassigned					
R170	15Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-150-J
R171	1.6K	R: Metal Glaze 1 Watt ±5%			75042	RG32-162-J
R172	340Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-3400-F
R173	15Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-150-J
R174	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R175	51Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-510-J
R175-R177	10Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-100-J
R178	1.47K	R: Metal Film 1/4 Watt ±1%	5		75042	CEA-TO-1471-F

Table 6-4. Auxiliary Board (A2) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
R179	2.5K	R: Variable 1/4 Watt ±20%			97979	CLP-2.5K-M
R180	22Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-220-J
R181	137Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1370-F
R182	250Ω	R: Variable 1/4 Watt ±20%	1		97979	CLP-250-M
R183	240Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-241-J
R184	100K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-104-J
R185-R186	100Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-101-J
R187	51Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-510-J
R188	330Ω	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-331-J
R189	2.67K	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-2671-F
R190	511Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-5110-F
R191	137Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-1370-F
R192	Unassigned					
R193	49.9Ω	R: Metal Film 1/4 Watt ±1%			75042	CEA-TO-49R9-F
R194	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R195	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
R196	62Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-620-J
R197	4.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-472-J
R198-R199	6.8K	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-682-J
R200-R201	10Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-100-J
R202	61.9Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-61R9-F
R203	150Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1500-F
R204-R205	1K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-1001-F
R206	180K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-184-J
R207	3K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-302-J
R208-R209	100K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-104-J
R210	1K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-102-J
C1-C2	0.1µf	C: Ceramic 100 volts +80% -20%	35		56289	33C41C
C3	0.01µf	C: Ceramic 100 volts ±20%	3		56289	C023A101F103M
C4	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C5	2.4-24.5pf	C: Variable Air Dielectric	2		74970	189-509-5
C6-C7	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C8	10pf	C: Ceramic 1000 volts ±10%	3		56289	C030A102E100K
C9-C13	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C14	Unassigned					
C15	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C16-C19	50pf	C: Mica 500 volts ±10%	5		00853	CM05-ED-500K
C20	20µf	C: Electrolytic 16 volts +75% -10%	5		56289	30D206G016BB2
C21	0.01µf	C: Ceramic 100 volts ±20%			56289	C023A101F103M
C22	10pf	C: Ceramic 1000 volts ±10%			56289	C030A102F100K
C23	0.002µf	C: Ceramic 100 volts ±20%	1		56289	C016A102G202M
C24-C25	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C26	50pf	C: Mica 500 volts ±10%			00853	CM05-ED-500K
C27	24pf	C: Mica 500 volts ±10%	1		00853	CM05-ED-240K
C28	2.4-24.5pf	C: Variable Air Dielectric	2		74970	189-509-5
C29-C34	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C

Table 6-4. Auxiliary Board (A2) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
C35-C36	100pf	C: Ceramic 1000 volts ±10%	4		56289	C028A102E101K
C37-C40	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C41	Unassigned					
C42	0.001µf	C: Ceramic 100 volts ±20%	1		56289	C016A102G102M
C43	2.4-24.5pf	C: Variable Air Dielectric			74970	189-509-5
C44	20pf	C: Mica 500 volts ±10%	1		00853	CM05-CD-200K
C45	0.01µf	C: Ceramic 100 volts ±20%			56289	C023A101F103M
C46-C47	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C48	10pf	C: Ceramic 1000 volts ±10%	1		56289	C030A102E100K
C49-C50	20µf	C: Electrolytic 16 volts +75% -10%			56289	30D206G016BB2
C51	Unassigned					
C52-C56	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C57	Unassigned					
C58	15µf	C: Electrolytic 50 volts +75% -10%	2		56289	30D156G050CB2
C59-C60	20µf	C: Electrolytic 16 volts +75% -10%			56289	30D206G016BB2
C61-C64	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C65-C67	Unassigned					
C68	Select	C: Mica 500 volts (select)			04062	DM15-(select)
C69	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C70-C71	100pf	C: Ceramic 1000 volts ±10%	2		56289	C028A102E101K
C72	39pf	C: Mica 500 volts ±10%	1		00853	CM05-ED-390K
C73-C74	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C75	15µf	C: Electrolytic 50 volts +75% -10%			56289	30D156G050-CB2
Q1-Q2		TSTR: Silicon NPN	4		07263	2N 3261
Q3		TSTR: Silicon NPN	6		02735	2N 5187
Q4	Unassigned					
Q5		TSTR: Silicon PNP	3	P00347101	07421	
Q6-Q7		TSTR: Silicon NPN			07263	2N 3261
Q8		TSTR: Silicon PNP		P00347101	07421	
Q9	Unassigned					
Q10-Q11		TSTR: Silicon NPN			02735	2N 5187
Q12		TSTR: Silicon NPN	19		04713	2N 3904
Q13		TSTR: Silicon PNP	14		04713	2N 3906
Q14		TSTR: Silicon NPN			04713	2N 3904
Q15		TSTR: Unijunction	1		04713	2N 4851
Q16		TSTR: Silicon NPN			04713	2N 3904
Q17-Q18	Unassigned					
Q19		TSTR: Silicon PNP	3		07263	2N 4258
Q20		TSTR: Silicon NPN			02735	2N 5187
Q21		TSTR: Silicon NPN			04713	2N 3904
Q22-Q23		TSTR: Silicon PNP			04713	2N 3906
Q24-Q25		TSTR: Silicon NPN			04713	2N 3904
Q26		TSTR: Silicon PNP			04713	2N 3906
Q27		TSTR: Silicon NPN			04713	2N 3904
Q28-Q34		TSTR: Silicon PNP			04713	2N 3906
Q35-Q42		TSTR: Silicon NPN			04713	2N 3904

Table 6-4. Auxiliary Board (A2) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
Q43-Q44		TSTR: Silicon PNP			04713	2N 3906
Q45		TSTR: Silicon NPN			04713	2N 3904
Q46		TSTR: Silicon NPN			02735	2N 5187
Q47		TSTR: Silicon PNP			04713	2N 3906
Q48		TSTR: Silicon NPN			04713	2N 3904
Q49		TSTR: N Chan JFET	1	P00347203	07421	2N 4091
Q50-Q51		TSTR: Silicon NPN			04713	2N 3904
Q52		TSTR: Silicon PNP			07263	2N 4258
Q53-Q54		TSTR: Silicon NPN	2		02735	RCA 40235
Q55		TSTR: Silicon PNP		P00347101	07421	
Q56		TSTR: Silicon NPN			02735	2N 5187
Q57		TSTR: Silicon PNP			07263	2N 4258
Q58		TSTR: Silicon NPN			04713	2N 3904
Q59		TSTR: Silicon PNP			04713	2N 3906
Q60-Q61		TSTR: Silicon NPN			04713	2N 3904
CR1-CR6		Diode: Silicon	33		03508	1N 914A
CR7	Unassigned					
CR8-CR26		Diode: Silicon			03508	1N 914A
CR27		Diode: Silicon 100 volts, 1A	1		04713	1N 4002
CR28-CR31		Diode: Silicon			03508	1N 914A
CR32-CR35	Unassigned					
CR36-CR37		Diode: Silicon			03508	1N 914A
CR38	Unassigned					
CR39-CR40		Diode: Silicon			03508	1N 914A
CR41		Diode: Switching, Hot Carrier	1		28480	HP 5082-2811
CR42	Unassigned					
CR43-CR46		Diode: Silicon			03508	1N 914A
IC1-IC2		Integrated Circuit (μA710C)	2		03877	TDC 2710E
IC3-IC7		Integrated Circuit, TTL Logic DIP	5		93332	SG 223-01
IC8		Integrated Circuit (μA702C)			07933	RC 702C
IC9-IC10		Integrated Circuit, TTL Logic DIP			93332	SG 223-01
L1-L2	10μh	Inductor, Fixed ±10%	2		76493	9310-36
L3	3.9μh	Inductor, Fixed ±10%	1		76493	9310-26
RN1-RN2		Resistor Network	2	P00334023	07421	
		Bead, Shielding	8		02114	K5001003B
TP1-TP35		Test Points	87		00779	61067-1
E1-E15		Contact	15		00779	60789-3
E1-E38		Test Points			00779	61067-1
S1		Switch, Offset with POT	1	P00333073	07421	
S2		Switch, Mode	1	P00334030	07421	
S3		Switch, Reset, Cal, Trig, Slipe, Man, Pwr	1	P00334031	07421	
DS1		Lamp	1	P00347900	07421	
J1-J2		Connector, 19 Pin	2		00779	1-85928-1
		Receptacle, Bulkhead, BNC, Round Mtg. Flange (used with Basic Model)	9	Y70B3000	02660	UG-625B/U
		Wire, Kynar 2, 24 AWG	A/R	516-061-001		

Table 6-4. Auxiliary Board (A2) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
		Coax Cable	A/R		02660	RG174U
		Wire, 24 AWG, T/P, WHT/BLK	A/R	515-020-249	07421	
		Wire, 22 AWG, T/P, WHT/BLK	A/R	515-020-229	07421	
P4		Pin, Housing	1		00779	1-480314-0
P4		Pin, 22-18 AWG	2		00779	60618-1
		Cable Assembly, 19 Pin	2	P00333600-3	07421	
			1			

TABLE 6-5. POWER SUPPLY BOARD (A3) PARTS LIST

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
A3		P. C. Board Ass'y, Power Supply	Ref	P00334300-1	07421	
		P. C. Board Ass'y, Power Supply	Ref	P00334300-2	07421	
R1-R2	4.3Ω	R: Carbon 1/4 Watt ±5%	4		75042	RC07GF-4R3-J
R3	680Ω	R: Metal Glaze 1/4 Watt ±5%	6		75042	RG1/4-681-J
R4	1.3K	R: Metal Glaze 1/2 Watt ±5%	2		75042	RG20-132-J
R5	2K	R: Metal Glaze 1/4 Watt ±5%	6		75042	RG1/4-202-J
R6	1.5K	R: Metal Glaze 1/4 Watt ±5%	6		75042	RG1/4-152-J
R7	2.7K	R: Metal Glaze 1/4 Watt ±5%	6		75042	RG1/4-272-J
R8-R9	10K	R: Metal Film 1/4 Watt ±0.25%	2		75042	CEA-TO-1002-C
R10	680Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-681-J
R11	1.3K	R: Metal Glaze 1/2 Watt ±5%			75042	RG20-132-J
R12	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R13	1.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-152-J
R14	2.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-272-J
R15	12.4K	R: Metal Film 1/4 Watt ±0.25%	1		75042	CEA-TO-1002-C
R16	6190Ω	R: Metal Film 1/4 Watt ±0.25%	1		75042	CEA-TO-1002-C
R17-R18	4.3Ω	R: Carbon 1/4 Watt ±5%			75042	RC07GF-4R3-J
R19	Unassigned					
R20	1.0Ω	R: Wirewound 2 Watt ±5%	2		75042	BWH-1R0-J
R21	680Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-681-J
R22	390Ω	R: Metal Glaze 1/2 Watt ±5%	2		75042	RG20-391-J
R23	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R24	1.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-152-J
R25	3K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-302-J
R26	2.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-272-J
R27	2K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-2001-F
R28	1K	R: Variable 1/4 Watt ±20%	1		97979	CLP-1K-M
R29	2.67K	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-2671-F
R30	680Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-681-J
R31	390Ω	R: Metal Glaze 1/2 Watt ±5%			75042	RG20-391-J
R32	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R33	1.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-152-J
R34	2.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-272-J
R35-R36	4750Ω	R: Metal Film 1/4 Watt ±0.25%	2		75042	CEA-TO-4751-C
R37	1.0Ω	R: Wirewound 2 Watt ±5%			75042	BWH-1R0-J
R38	Unassigned					
R39	3.3Ω	R: Carbon 1/4 Watt ±5%	1		75042	RC07GF-3R3-J
R40	3.0Ω	R: Carbon 1/4 Watt ±5%			75042	RC07GF-3R0-J
R41	680Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-681-J
R42	160Ω	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-161-J
R43	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R44	1.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-152-J
R45	2.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-272-J
R46-R47	2210Ω	R: Metal Film 1/4 Watt ±0.25%	2		75042	CEA-TO-2211-C
R48	680Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-681-J
R49	160Ω	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-161-J

Table 6-5. Power Supply Board (A3) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
R50	2K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-202-J
R51	1.5K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-152-J
R52	2.7K	R: Metal Glaze 1/4 Watt ±5%			75042	RG1/4-272-J
R53	5620Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-5621-F
R54	500Ω	R: Variable 1/4 Watt ±20%	1		97979	CLP-500-M
R55	2210Ω	R: Metal Film 1/4 Watt ±1%	1		75042	CEA-TO-2211-F
R56-R57	5.1Ω	R: Carbon 1/4 Watt ±5%	2		75042	RC07GF-5R1-J
R58	Unassigned					
R59-R60	5.1K	R: Metal Glaze 1/2 Watt ±5%	2		75042	RG20-512-J
R61-R66	91Ω	R: Metal Glaze 1/4 Watt ±5%	6		75042	RG1/4-910-J
R67-R68	220K	R: Metal Glaze 1/4 Watt ±5%	2		75042	RG1/4-224-J
R69	68K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-683-J
R70	120K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-124-J
R71	30K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-303-J
R72	43K	R: Metal Glaze 1/4 Watt ±5%	1		75042	RG1/4-433-J
C1	1250µf	C: Electrolytic 50 volts +150% -10%	2		90201	20-35890
C2	200pf	C: Mica 500 volts ±20%	6		00853	CM05-ED-201K
C3	20pf	C: Mica 500 volts ±10%	6		00853	CM05-ED-200K
C4	100µf	C: Electrolytic 50 volts +100% -10%	4		90201	20-44818
C5	0.1µf	C: Ceramic 100 volts +80% -20%	14		56289	33C41C
C6	1250µf	C: Electrolytic 50 volts +150% -10%			90201	20-35890
C7	20pf	C: Mica 500 volts ±10%			00853	CM05-ED-200K
C8	200pf	C: Mica 500 volts ±10%			00853	CM05-ED-201K
C9	100µf	C: Electrolytic 50 volts +100% -10%			90201	20-44818
C10	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C11	200pf	C: Mica 500 volts ±10%			00853	CM05-ED-201K
C12	20pf	C: Mica 500 volts ±10%			00853	CM05-ED-200K
C13	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C14	100µf	C: Electrolytic 50 volts +100% -10%			90201	20-44818
C15	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C16-C17	1500µf	C: Electrolytic 25 volts +150% -10%	2		90201	20-35889
C18	20pf	C: Mica 500 volts ±10%			00853	CM05-ED-200K
C19	200pf	C: Mica 500 volts ±10%			00853	CM05-ED201K
C20	100µf	C: Electrolytic 50 volts +100% -10%			90201	20-44818
C21	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C22	2500µf	C: Electrolytic 15 volts +150% -10%	2		90201	20-35891
C23	2pf	C: Mica 500 volts ±0.5pf	2		04062	DM15-020-K
C24	200pf	C: Mica 500 volts ±10%			00853	CM05-ED-201K
C25	100µf	C: Electrolytic 15 volts +150% -10%	2		90201	20-44823
C26	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C27	2500µf	C: Electrolytic 15 volts +150% -10%			90201	20-35891
C28	2pf	C: Mica 500 volts ±0.5pf			04026	DM15-020-K
C29	200pf	C: Mica 500 volts ±10%			00853	CM05-ED-201K
C30	100µf	C: Electrolytic 15 volts +150% -10%			90201	20-44823
C31-C32	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C
C33-C38	0.1µf	C: Ceramic 100 volts +80% -20%			56289	33C41C

Table 6-5. Power Supply Board (A3) Parts List (Continued)

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
C39-C44	0.01µf	C: Ceramic 100 volts ±20%	6		56289	C023A101F103M
Q1		TSTR: Silicon PNP	3		01295	TIP30A
Q2		TSTR: Silicon PNP	2		02735	2N 4036
Q3		TSTR: Silicon NPN	2		02735	2N 2102
Q4		TSTR: Silicon PNP			02735	2N 4036
Q5		TSTR: Silicon NPN			02735	2N 2102
Q6		TSTR: Silicon NPN	3		01295	TIP29A
Q7		TSTR: Silicon PNP			02195	TIP30A
Q8		TSTR: Silicon PNP	4		56289	TQ 59
Q9		TSTR: Silicon NPN	4		56289	TN 59
Q10		TSTR: Silicon PNP			56289	TQ 59
Q11		TSTR: Silicon NPN			56289	TN 59
Q12		TSTR: Silicon NPN			01295	TIP29A
Q13		TSTR: Silicon PNP			01295	TIP30A
Q14		TSTR: Silicon PNP			56289	TQ 59
Q15		TSTR: Silicon NPN			56289	TN 59
Q16		TSTR: Silicon PNP			56289	TQ 59
Q17		TSTR: Silicon NPN			56289	TN 59
Q18		TSTR: Silicon NPN			01295	TIP29A
CR1-CR4		Diode: Silicon 100 volts PRV 1 Amp	12		04713	1N 4002
CR5-CR10		Diode: Silicon	23		03508	1N 914A
CR11-CR14		Diode: Silicon 100 volts PRV 1 Amp			04713	1N 4002
CR15-CR19		Diode: Silicon			03508	1N 914A
CR20		Diode: Zener 6.2 volts 500 mw ±5%	1		04713	1N 5234B
CR21-CR26		Diode: Silicon			03508	1N 914A
CR27-CR30		Diode: Silicon 100 volts PRV 1 Amp			04713	1N 4002
CR31-CR36		Diode: Silicon			03508	1N 914A
IC1-IC6		Integrated Circuit (µA709C) DIP	6		03877	TOA2709E
S1		Switch, Slide, DPDT	1		82389	46256LF
T1		Transformer, Power	1	P00333420	07421	
F1	1/2 Amp/ 115v- 1/4 Amp/ 230v	Fuse, 3AG SLO-BLO	1		75915	3AG1/2A
J3		Connector, P.C. Board, Double Readout	1		71785	252-20-30-161
		Cord, Power, 3 Conductor	1		70903	17237-SVT
J4		Socket, 18-22 AWG	2		00779	60617-1
J4		Housing	1		00779	1-480318-0
TP1-TP7		Test Points	7		00779	61067-1
		Receptacle, Bulkhead, BNC, Round Mtg. Flange (used with Rack Mount)	9		02660	UG-625B/U
		Wire, 22 AWG T/P WHT/BLK	A/R	515-020-229	07421	
		Coax Cable	A/R		02660	RG174U
		Contact	18		00779	60789-3
		Ferrule, Outer	1	371-392-175	07421	
		Ferrule, Inner	1	371-391-109	07421	
		Wire, 22 AWG, Twisted Shielded Pair, WHT/BLK		516-002-220	07421	

TABLE 6-6. MECHANICAL PARTS LIST

REF DESIG	VALUE	DESCRIPTION	T.Q.	IEC P/N	MFR	MFR P/N
		Fuse Post, Miniature, 3AG	1		75915	342022
		Bushing, Strain Relief, Black	1		28520	SR-5P-4
		Stand Off, 7/8", 4-40	2		06540	8219-B-0440
		Shaft Extender	1	P00334028	07421	
		Bracket, Pot Mounting	2	P00334022	07421	
		Shield, Attenuator Switch	2	P00334047	07421	
		Rod, Support	2	P00334050	07421	
		Sub-Panel, Lower	1	P00334044	07421	
		Sub-Panel, Upper	1	P00334045-1	07421	
		Ball Drive, 6:1	1	P00333020	07421	
		Control Arm	1	P00333143	07421	
		Nut Plate, Floating, Right Angle	6		13740	MF 6000-06
		Stand Off, Hex Swage	2	P00333320	07421	
		Pad, Beige	2		76381	5017
		Spacer	10	464-099-001	07421	
		Spacer, #4 x 0.25 LG			83330	2340
		Thermal Link, A2-Q1 & A2-Q2	1		05820	259-0.400
		Heatsinks, A3: -Q1, -Q6, -Q7, -Q12, -Q13 & -Q18	6	P00333540-1	07421	
		Heat Dissipators, A1-Q19 & A1-Q20	2		98978	TXBF-019-025B
		Heat Dissipators, A1-Q24 & A1-Q25	2		98978	TXB2-032-037
		Heat Dissipators, A1-Q21 & A1-Q22	2		05820	Type 292A
		Grommet, Rubber	1		77969	RC15
		Lug	2	371-203-012	07421	
		Set Screw, Cres with Cup Point	1		56878	#4-40 x 0.50 LG
		Set Screw, Cres with Cup Point	1		56878	#4-40 x 0.25 LG
		Heat Dissipator, A1-Q11 & A1-IC5	2		98978	TXBF-032-025B
		Heat Sink	1	P00333540-3	07421	
		Stand Off, Aluminum, 3/16 Dia. x 0.312 LG	2		06540	8078-A-0440
		Transipad, A1-Q21 & A1-Q22	2	464-002-020	07421	
		Pin, 0.039 Dia. x 3/8 LG	1		00287	0.039 x 3/8 MDP

Section VII
CIRCUIT DIAGRAMS

7-1. INTRODUCTION

This section contains the functional block diagram, detailed schematic diagrams, and component location diagrams and tables for the Function Generator Models F54/F55.

7-2. FUNCTIONAL BLOCK DIAGRAM

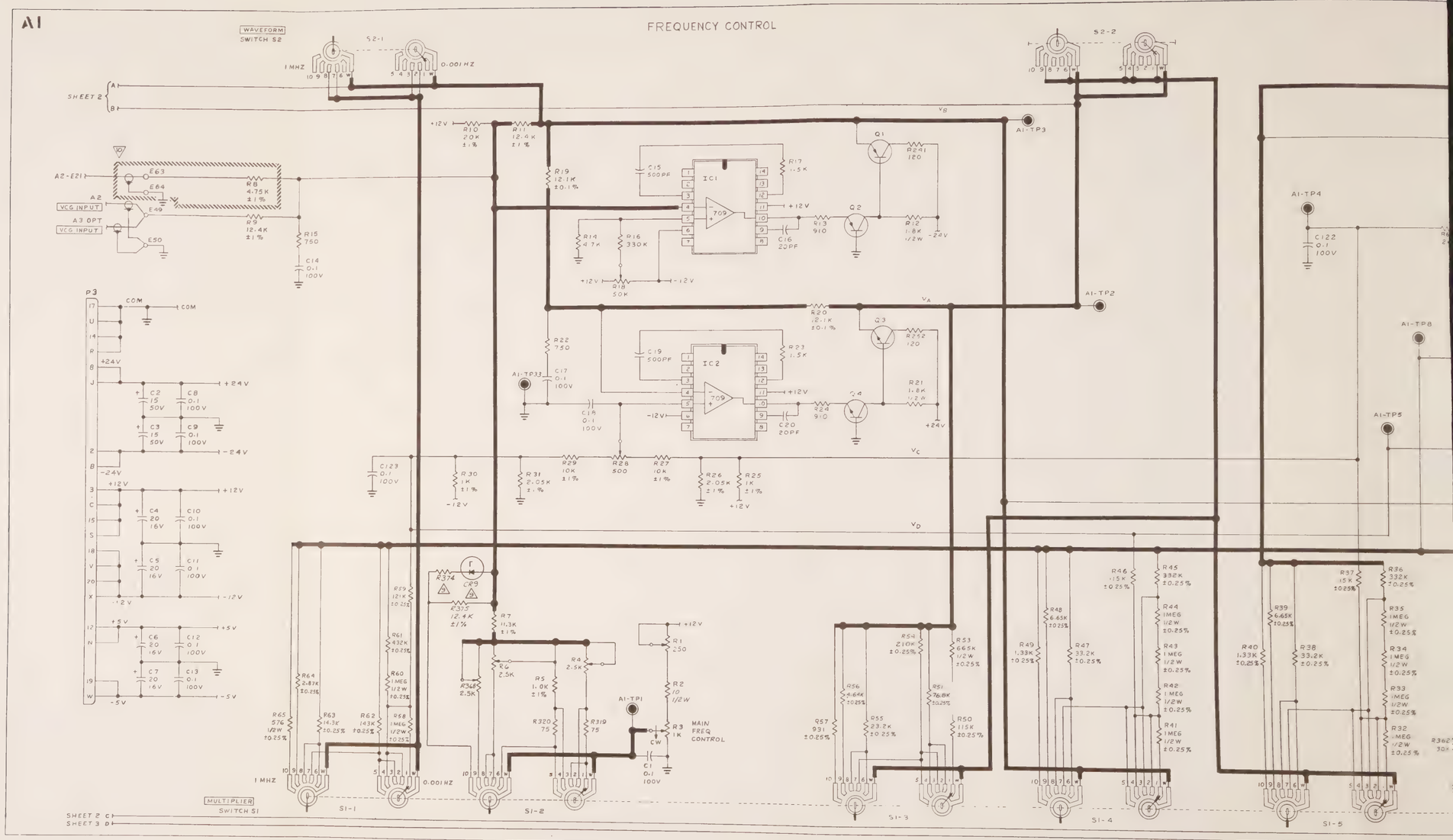
Figure 7-1 is a functional block diagram of the entire function generator showing important test points and the variable components used in the adjustment and calibration procedure.

7-3. SCHEMATIC DIAGRAMS

Figures 7-3, 7-5, and 7-7 are detailed schematic diagrams of the circuits in the function generator. Special emphasis has been placed on illustrating all integrated circuit packages in their top view position and actual physical appearance. All wafer-type switches are physically illustrated with their connecting components. An overall unit schematic diagram, showing the major signal path in heavy lines, is also supplied, in separate cover, with this manual. Included on this complete schematic are test point waveforms and measurements, test point locations, and adjustment locations.

7-4. COMPONENT LOCATION DIAGRAMS

Figures 7-2, 7-4, and 7-6 are component location (assembly) diagrams. These assembly diagrams, and tables 7-1 through 7-3, will assist in the identification and location of components and test points on each board.


A1
FREQUENCY CONTROL
WAVEFORM SWITCH S2
S2-1
S2-2
1 MHZ
0.001 HZ
SHEET 2 A
SHEET 2 B
A2-E21
A2 VCG INPUT
A3 OPT VCG INPUT
E63
E64
E49
E50
R8 4.75K ±1%
R9 12.4K ±1%
R15 750
C14 0.1 100V
P3
COM
+24V
-24V
+12V
-12V
+5V
-5V
C2 15 50V
C3 15 50V
C8 0.1 100V
C9 0.1 100V
C4 20 16V
C10 0.1 100V
C5 20 16V
C11 0.1 100V
C6 20 16V
C12 0.1 100V
C7 20 16V
C13 0.1 100V
R10 20K ±1%
R11 12.4K ±1%
R19 12.1K ±0.1%
R17 1.5K
R241 120
R12 1.8K 1/2W
R13 910
R14 4.7K
R16 330K
R18 50K
C15 500PF
C16 20PF
IC1
709
Q1
Q2
VB
A1-TP3
A1-TP4
C122 0.1 100V
R20 12.1K ±0.1%
VA
A1-TP2
R22 750
A1-TP33
C17 0.1 100V
C19 500PF
C18 0.1 100V
C20 20PF
IC2
R23 1.5K
R252 120
R21 1.8K 1/2W
R24 910
Q3
Q4
A1-TP8
A1-TP5
C123 0.1 100V
R30 1K ±1%
R31 2.05K ±1%
R29 10K ±1%
R28 500
R27 10K ±1%
R26 2.05K ±1%
R25 1K ±1%
VC
VD
R374
C29
R375 12.4K ±1%
R7 11.3K ±1%
R6 2.5K
R5 1.0K ±1%
R4 2.5K
R368 2.5K
R320 75
R319 75
R1 250
R2 10 1/2W
R3 1K
A1-TP1
CW
C1 0.1 100V
MAIN FREQ CONTROL
R59 121K ±0.25%
R61 432K ±0.25%
R60 1MEG 1/2W ±0.25%
R58 1MEG 1/2W ±0.25%
R64 2.87K ±0.25%
R63 14.3K ±0.25%
R62 143K ±0.25%
R65 576 1/2W ±0.25%
R54 210K ±0.25%
R53 665K 1/2W ±0.25%
R56 4.64K ±0.25%
R51 76.8K ±0.25%
R57 931 ±0.25%
R55 23.2K ±0.25%
R50 11.5K ±0.25%
R46 11.5K ±0.25%
R45 332K ±0.25%
R48 6.65K ±0.25%
R49 1.33K ±0.25%
R47 33.2K ±0.25%
R44 1MEG 1/2W ±0.25%
R43 1MEG 1/2W ±0.25%
R42 1MEG 1/2W ±0.25%
R41 1MEG 1/2W ±0.25%
R37 11.5K ±0.25%
R36 332K ±0.25%
R39 6.65K ±0.25%
R35 1MEG 1/2W ±0.25%
R40 1.33K ±0.25%
R38 33.2K ±0.25%
R34 1MEG 1/2W ±0.25%
R33 1MEG 1/2W ±0.25%
R32 1MEG 1/2W ±0.25%
R362 30K
MULTIPLIER SWITCH S1
S1-1
S1-2
S1-3
S1-4
S1-5
SHEET 2 C
SHEET 3 D

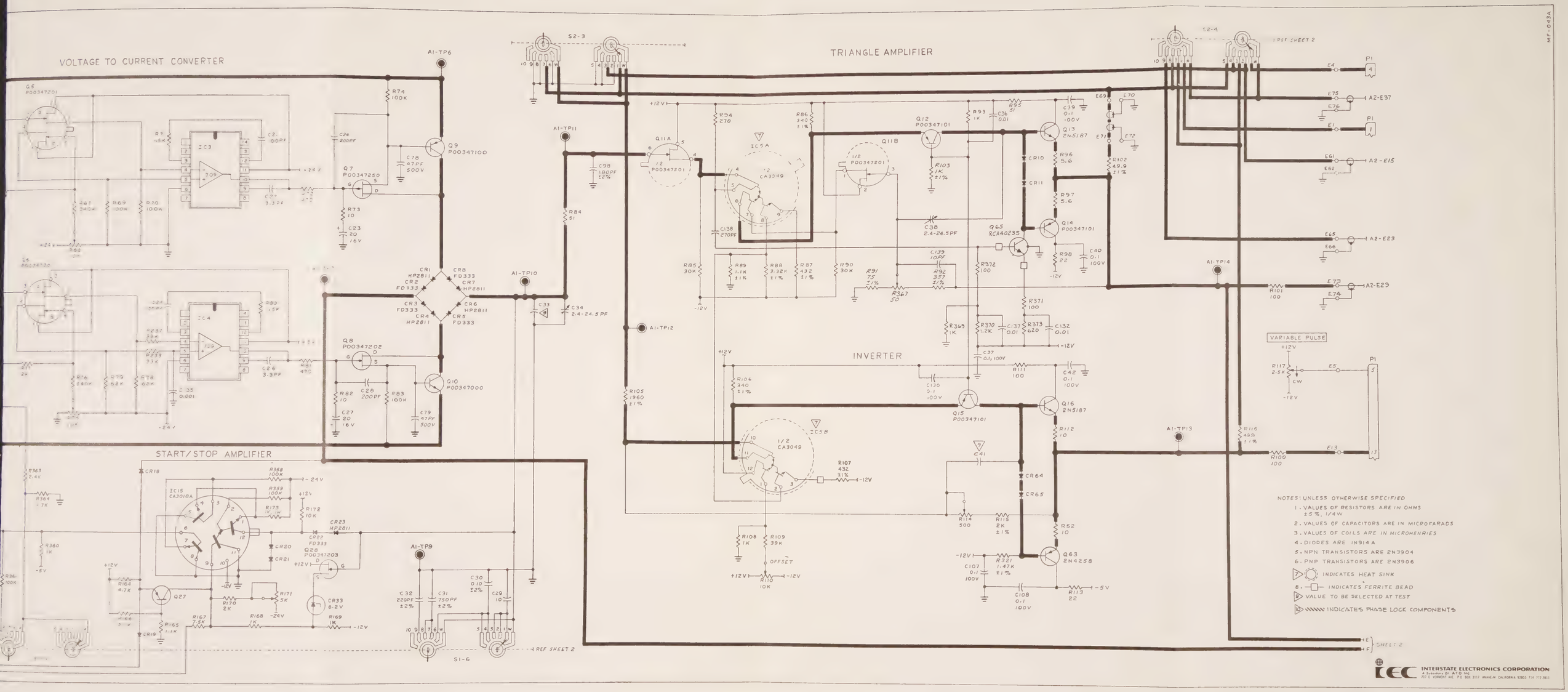
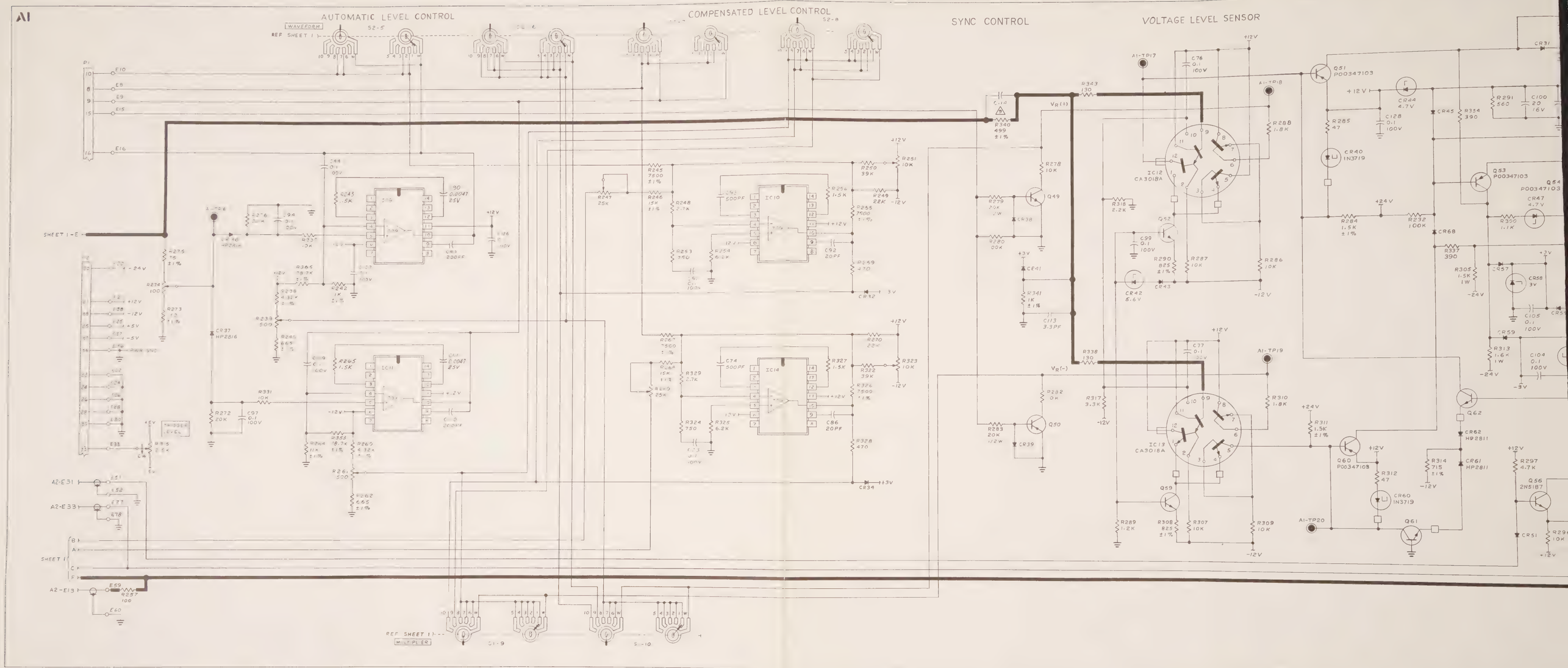

VOLTAGE TO CURRENT CONVERTER
TRIANGLE AMPLIFIER
INVERTER
START/STOP AMPLIFIER
VARIABLE PULSE
NOTES: UNLESS OTHERWISE SPECIFIED
1. VALUES OF RESISTORS ARE IN OHMS ±5%, 1/4W
2. VALUES OF CAPACITORS ARE IN MICROFARADS
3. VALUES OF COILS ARE IN MICROHENRIES
4. DIODES ARE 1N914A
5. NPN TRANSISTORS ARE 2N3904
6. PNP TRANSISTORS ARE 2N3906
INDICATES HEAT SINK
INDICATES FERRITE BEAD
VALUE TO BE SELECTED AT TEST
INDICATES PHASE LOCK COMPONENTS
INTERSTATE ELECTRONICS CORPORATION

Figure 7-3. Main Board (A1) Schematic (Sheet 1 of 3 sheets)


A1
AUTOMATIC LEVEL CONTROL
COMPENSATED LEVEL CONTROL
SYNC CONTROL
VOLTAGE LEVEL SENSOR
WAVEFORM
REF SHEET 1
MULTIPLER
SHEET 1
A2-E31
A2-E33
A2-E13
IC10
IC11
IC12 CA3018A
IC13 CA3018A
IC14
Q49
Q50
Q51 P00347103
Q52
Q53 P00347103
Q54 P00347103
Q59
Q60 P00347103
Q61
Q62
Q56 2N5187
CR37 HP2816
CR38
CR39
CR40 IN3719
CR41
CR42 5.6V
CR43
CR44 4.7V
CR45
CR47 4.7V
CR57
CR58 3V
CR59
CR60 IN3719
CR61 HP2811
CR62 HP2811
CR68
CR31
CR32
CR34
CR51
A1-TP17
A1-TP18
A1-TP19
A1-TP20
VR(+)
VR(-)
+12V
-12V
+24V
-24V
+3V
-3V
+4.2V
+5V

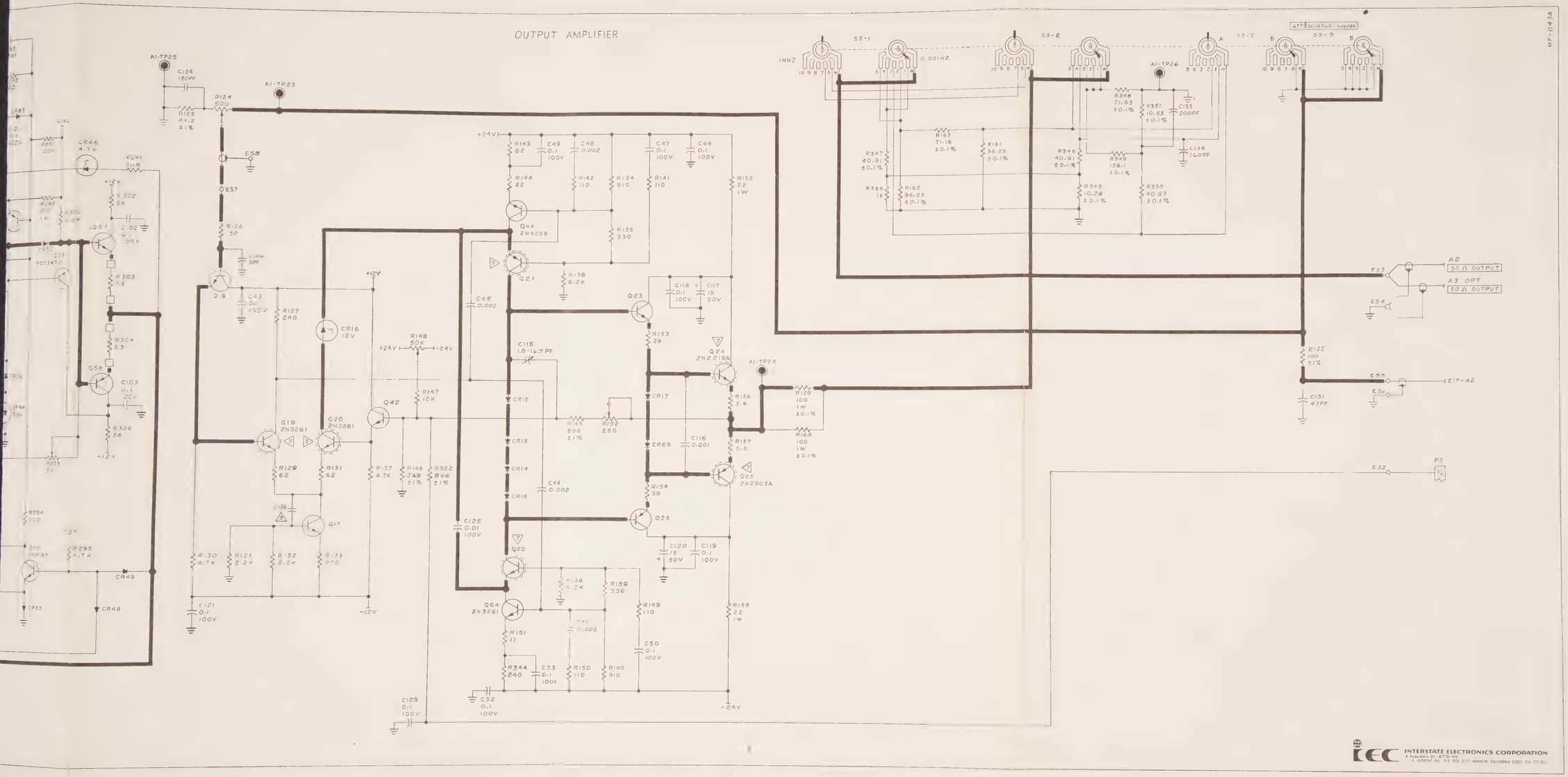
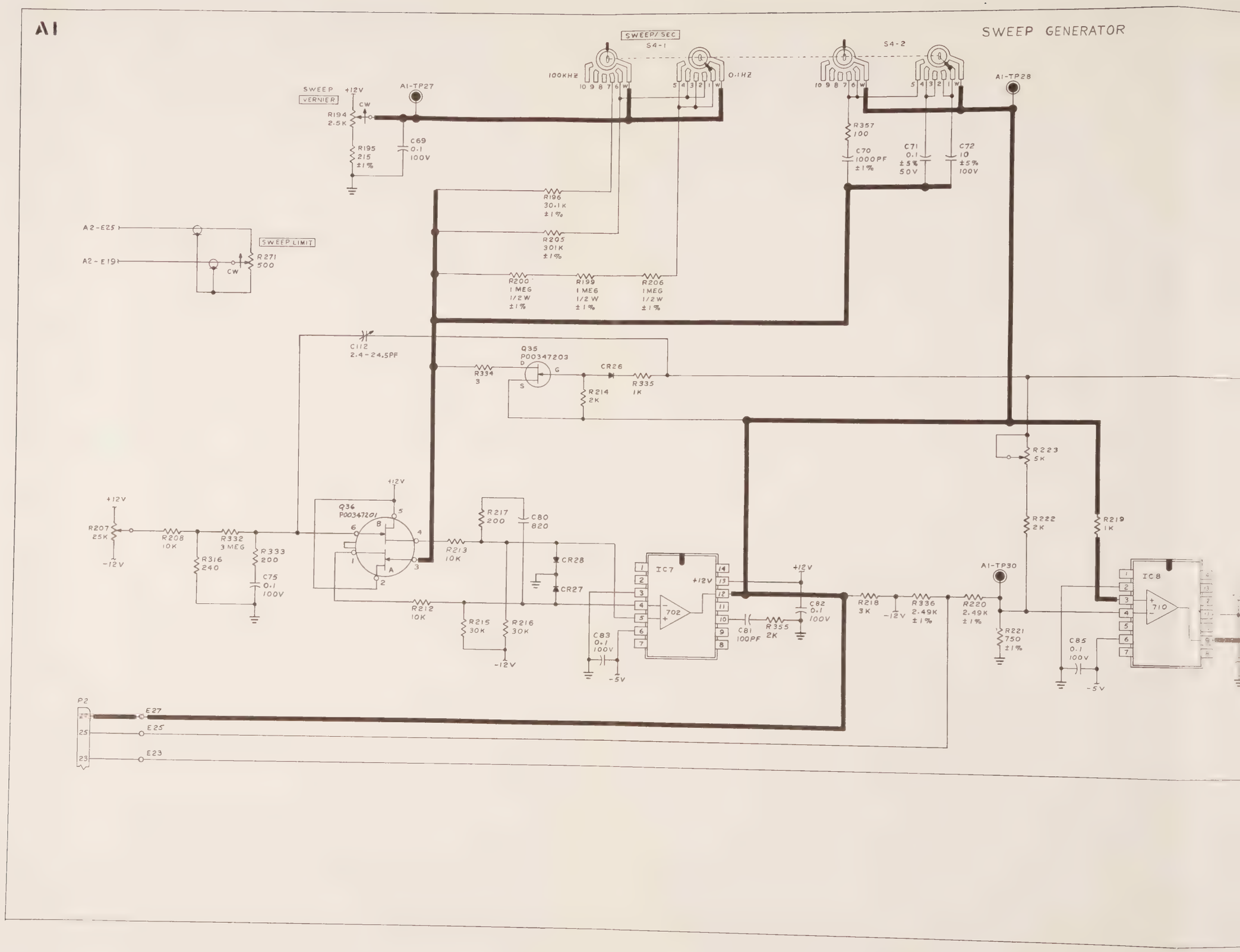
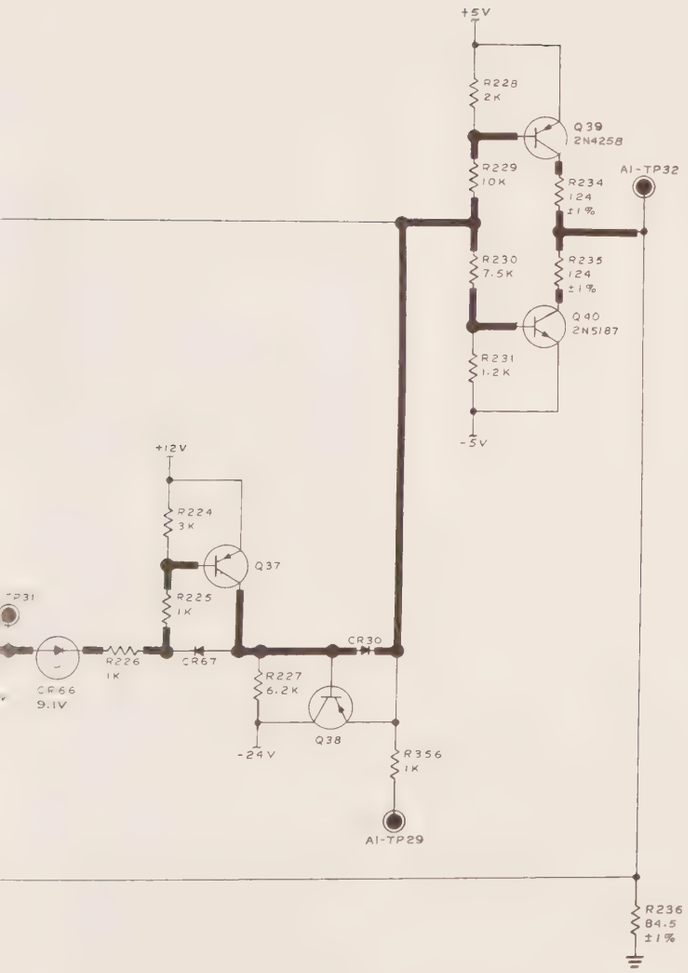


Figure 7-3. Main Board (A1) Schematic (Sheet 2)


A1
SWEEP GENERATOR
SWEEP/SEC
S4-1
S4-2
100KHZ
0.1HZ
A1-TP27
A1-TP28
SWEEP VERNIER
+12V
CW
R194 2.5K
R195 215 ±1%
C69 0.1 100V
R357 100
C70 1000PF ±1%
C71 0.1 ±5% 50V
C72 10 ±5% 100V
R196 30.1K ±1%
R205 301K ±1%
A2-E25
A2-E19
SWEEP LIMIT
R271 500
R200 1 MEG 1/2W ±1%
R199 1 MEG 1/2 W ±1%
R206 1 MEG 1/2W ±1%
C112 2.4-24.5PF
Q35 P00347203
R334 3
CR26
R335 1K
R214 2K
R223 5K
R222 2K
R219 1K
Q36 P00347201
R207 25K
R208 10K
R332 3 MEG
R316 240
R333 200
C75 0.1 100V
R213 10K
R217 200
C80 820
CR28
CR27
R212 10K
R215 30K
R216 30K
C83 0.1 100V
IC7
702
C81 100PF
R355 2K
C82 0.1 100V
R218 3K
R336 2.49K ±1%
R220 2.49K ±1%
A1-TP30
R221 750 ±1%
IC8
710
C85 0.1 100V
-12V
-5V
P2
E27
E25
E23



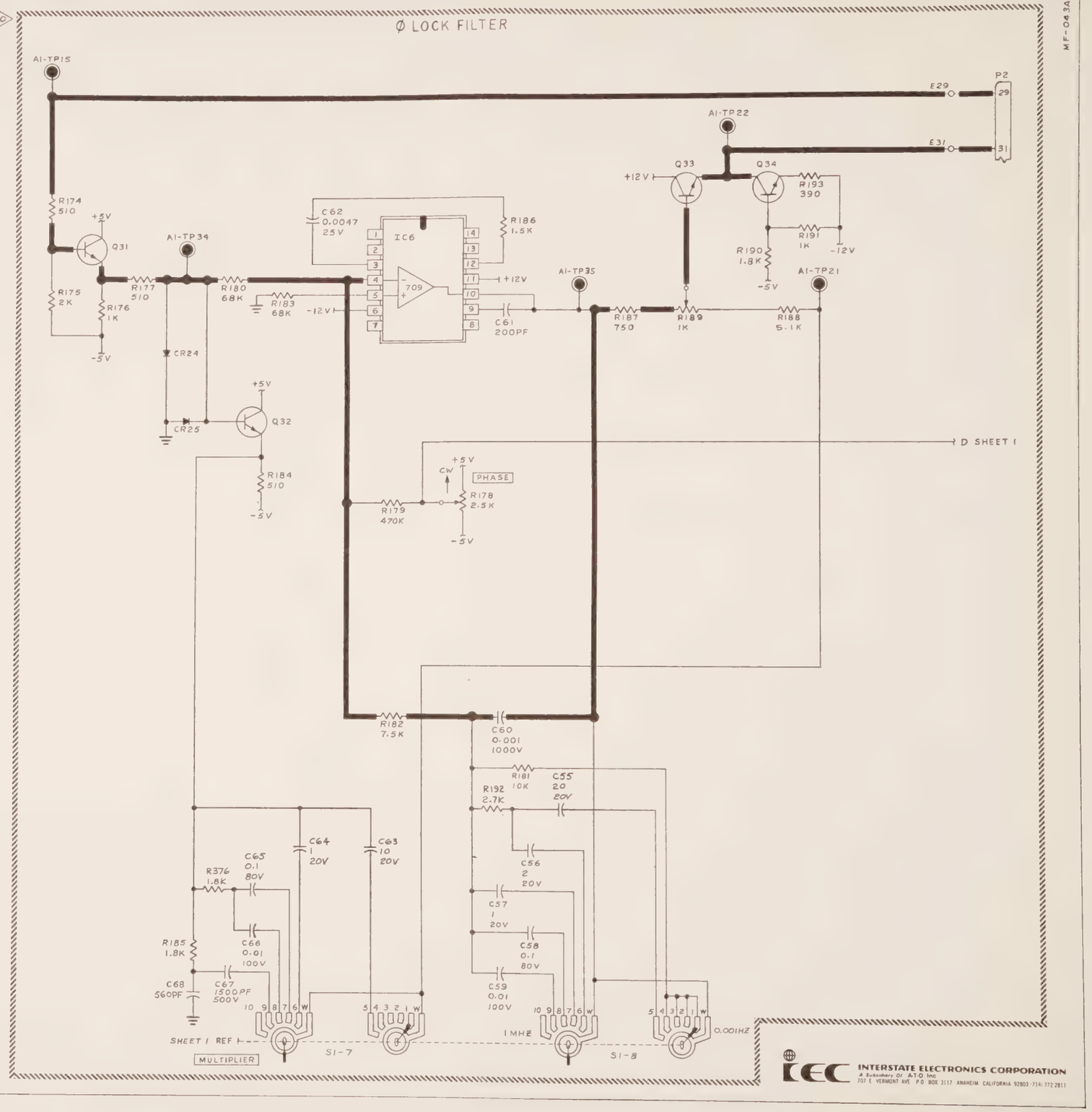
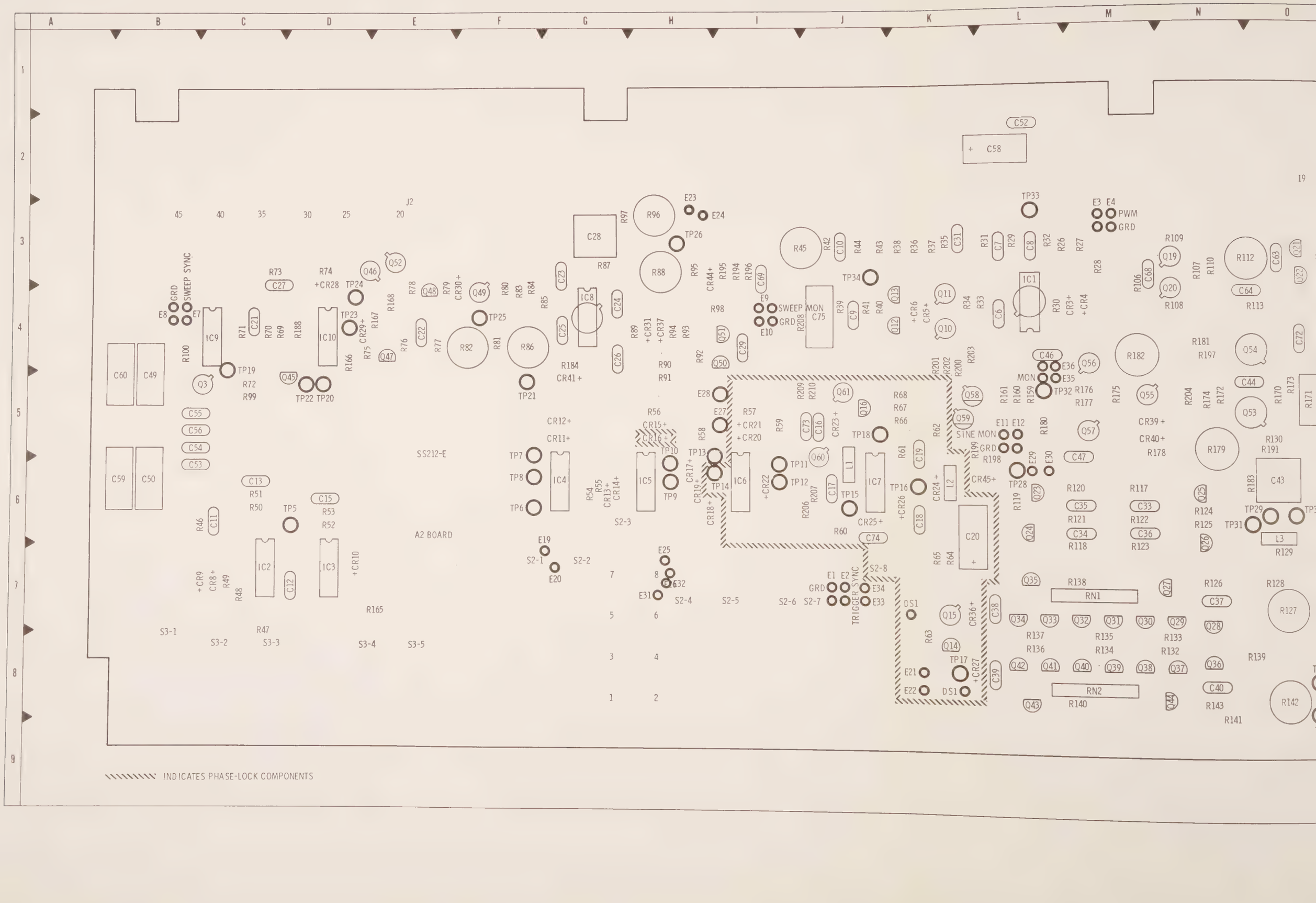


Figure 7-3. Main Board (A1) Schematic (Sheet 3 of 3 sheets)


A2 BOARD
SS212-E
INDICATES PHASE-LOCK COMPONENTS
J2
IC1
IC2
IC3
IC4
IC5
IC6
IC7
IC8
IC9
IC10
RN1
RN2
C20
C28
C58
R45
R96
R88
R82
R86
R112
R182
R179
TP33
TP34
TP26
TP24
TP25
TP23
TP22
TP20
TP21
TP19
TP18
TP17
TP16
TP15
TP14
TP13
TP12
TP11
TP10
TP9
TP8
TP7
TP6
TP5
TP31
E3 E4
PWM
GRD
SWEEP
MON
SINE MON
TRIGGER SYNC
SWEEP SYNC
S2-1
S2-2
S2-3
S2-4
S2-5
S2-6
S2-7
S2-8
S3-1
S3-2
S3-3
S3-4
S3-5
DS1
L1
L2
L3

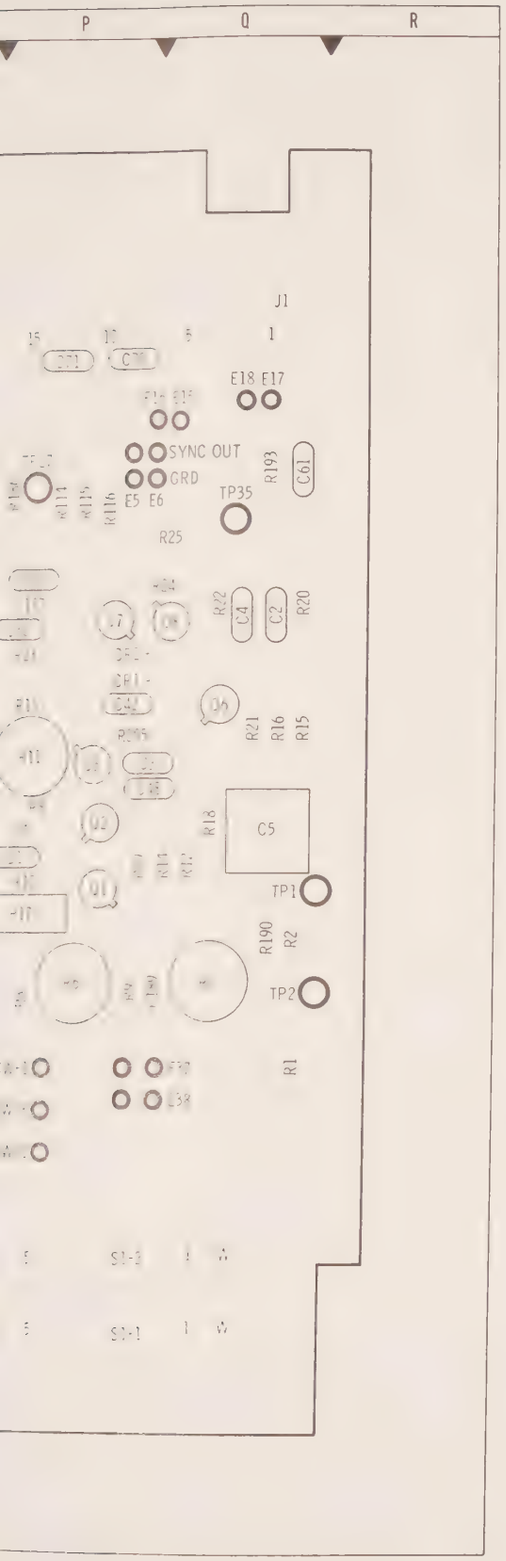


TABLE 7-2. AUXILIARY BOARD (A2) COMPONENT LOCATIONS

MF-053A

REF DESIG	ZONE	REF DESIG	ZONE	REF DESIG	ZONE	REF DESIG	ZONE	REF DESIG	ZONE	REF DESIG	ZONE	REF DESIG	ZONE
C1	P5	C74	J6	Q13	K3	R22	Q4	R88	H3	R180	L5	TP35	Q3
C2	Q4	C75	J4	Q14	K8	R23	P4	R89	H4	R181	N4	E1	J7
C3	P4	CR1	P4	Q15	K7	R24	Q4	R90	H4	R182	M4	E2	J7
C4	Q4	CR2	P4	Q16	J5	R25	Q3	R91	H4	R183	G6	E3	M3
C5	Q5	CR3	M4	Q17	N3	R26	M3	R92	H4	R184	G4	E4	M3
C6	L4	CR4	M4	Q20	N3	R27	M3	R93	H4	R185	Q3	E5	P3
C7	L3	CR5	N4	Q21	O3	R28	M3	R94	H4	R186	P3	E6	Q3
C8	L3	CR6	N4	Q22	O3	R29	L3	R95	H3	R187	P4	E7	B4
C9	J4	CR8	C7	Q23	L6	R30	L4	R96	H2	R188	D4	E8	B4
C10	J3	CR9	C7	Q24	L6	R31	L3	R97	G3	R189	Q6	E9	I4
C11	C6	CR10	D7	Q25	N6	R32	L3	R98	I4	R190	Q6	E10	I4
C12	D7	CR11	G5	Q26	N6	R33	L4	R99	C5	R191	O5	E11	L5
C13	C6	CR12	G5	Q27	N7	R34	N4	R100	B4	R193	Q3	E12	L5
C14	C6	CR13	G6	Q28	N7	R35	K3	R106	M3	R194	I3	E13	N3
C15	J5	CR14	G6	Q29	N7	R36	K3	R107	N3	R195	I3	E14	N3
C17	J6	CR15	H5	Q30	M7	R37	K3	R108	N4	R196	I3	E15	Q3
C18	K6	CR16	H5	Q31	M7	R38	K3	R109	N3	R197	N4	E16	Q3
C19	K5	CR17	H6	Q32	M7	R39	J4	R110	N3	R198	L5	E17	Q3
C20	L6	CR18	I6	Q33	L7	R40	J4	R112	C3	R199	L5	E18	Q3
C21	C4	CR19	H6	Q34	L7	R41	J4	R113	C4	R200	N4	E19	G6
C22	E4	CR20	I5	Q35	L7	R42	J3	R114	P3	R201	N4	E20	E7
C23	G3	CR21	I5	Q36	N8	R43	J3	R115	P3	R202	N4	E21	K8
C24	G4	CR22	I6	Q37	N8	R44	J3	R116	P3	R203	L4	E22	K8
C25	G4	CR23	J5	Q38	M8	R45	J3	R117	M6	R204	N5	E23	H2
C26	G4	CR24	K6	Q39	M8	R46	C6	R118	M6	R205	P5	E24	H2
C27	C3	CR25	J6	Q40	M8	R47	C7	R119	L6	R206	J6	E25	H7
C28	G3	CR26	K6	Q41	L8	R48	C7	R120	M6	R207	J6	E26	H7
C29	I4	CR27	J6	Q42	L8	R49	C7	R121	M6	R208	J4	E27	I5
C30	P4	CR28	D3	Q43	L8	R50	C6	R122	M6	R209	J5	E28	F5
C31	K3	CR29	D4	Q44	N8	R51	C6	R123	M6	R210	J5	E29	L6
C32	P4	CR30	F3	Q45	D5	R52	D6	R124	N6	RN1	M7	E30	L6
C33	M6	CR31	H4	Q46	E3	R53	D6	R125	N6	RN2	M8	E31	H7
C34	M6	CR36	L7	Q47	E4	R54	G6	R126	N7	TP1	R5	E32	H7
C35	M6	CR37	H4	Q48	E3	R55	G6	R127	C7	TP2	R6	E33	J7
C36	M6	CR39	N5	Q49	F3	R56	H5	R128	O7	TP3	O8	E34	J7
C37	N7	CR40	N5	Q50	I4	R57	I5	R129	O6	TP4	O8	E35	L4
C38	L7	CR41	G4	Q51	I4	R58	H5	R130	O5	TP5	D6	E36	L4
C39	L6	CR43	L6	Q52	E3	R59	I5	R132	N8	TP6	G6	E37	P7
C40	N8	CR44	H3	Q53	O5	R60	J6	R133	N7	TP7	G5	E38	P7
C42	P4	CR45	L6	Q54	O4	R61	K5	R134	M8	TP8	G6		
C43	O5	DS1	K7 L8	Q55	M5	R62	K5	R135	M7	TP9	H6		
C44	O4	IC1	L4	Q56	M4	R63	K7	R136	L8	TP10	H5		
C45	N5	IC2	C7	Q57	M5	R64	K7	R137	L7	TP11	I5		
C46	L4	IC3	D7	Q58	L5	R65	K7	R138	M7	TP12	I6		
C47	M5	IC4	G6	Q59	L5	R66	K5	R139	O8	TP13	I5		
C48	O5	IC5	H6	R1	Q7	R67	K5	R140	M8	TP14	I6		
C49	B4	IC6	I6	R2	Q6	R68	K5	R141	O8	TP15	J6		
C50	B6	IC7	J6	R3	P6	R69	C4	R142	O8	TP16	K6		
C52	L2	IC8	G4	R4	P7	R70	C4	R143	N8	TP17	L8		
C53	B6	IC9	C4	R5	P5	R71	C4	R159	L5	TP18	K5		
C54	B5	IC10	D4	R6	P6	R72	C5	R160	L5	TP19	C4		
C55	B5	J1	Q2	R7	Q6	R73	C3	R161	L5	TP20	D5		
C56	B5	J2	E2	R8	P5	R74	D3	R165	E7	TP21	F5		
C58	L2	L1	J5	R9	P6	R75	E4	R166	D4	TP22	D5		
C59	B6	L2	K6	R10	P5	R76	E4	R167	E4	TP23	D4		
C60	B4	L3	G6	R11	P5	R77	E4	R168	E4	TP24	D4		
C61	Q3	Q1	P5	R12	Q5	R78	E3	R170	O5	TP25	F4		
C62	P6	Q2	P5	R13	P4	R79	E3	R171	O5	TP26	H3		
C63	O3	Q3	C5	R14	Q5	R80	F3	R172	N5	TP27	P3		
C64	O3	Q5	P5	R15	Q4	R81	F4	R173	O4	TP28	L5		
C68	M3	Q6	Q4	R16	Q4	R82	F4	R174	N5	TP29	O6		
C69	I3	Q7	P4	R17	P6	R83	F3	R175	M5	TP30	O6		
C70	P2	Q8	Q4	R18	Q5	R84	F3	R176	M5	TP31	O6		
C71	P2	Q10	K4	R19	Q5	R85	G4	R177	M5	TP32	L5		
C72	C4	Q11	K3	R20	Q4	R86	F4	R178	N5	TP33	L3		
C73	J5	Q12	K4	R21	Q4	R87	G7	R179	N5	TP34	J3		

Figure 7-4. Auxiliary Board (A2) Component Locations

A2

SINE SHAPER

SQUARE WAVE DRIVER

RN1 P00334-023

RN2 P00334-023

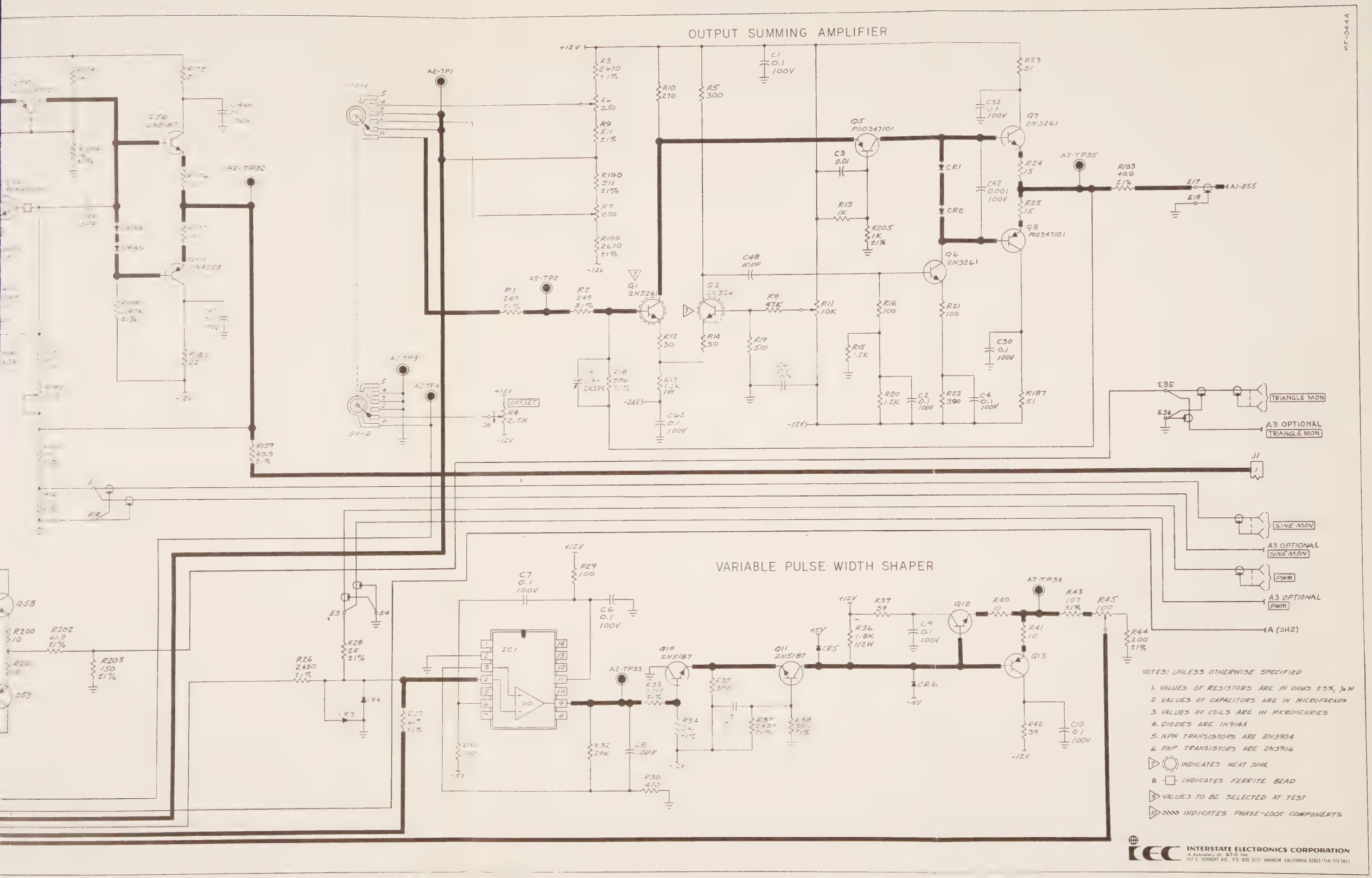


Figure 7-5. Auxiliary Board (A-2) Schematic (Sheet 1 of 2 sheets)

A2

TRIGGER LOGIC

MODE SWITCHES

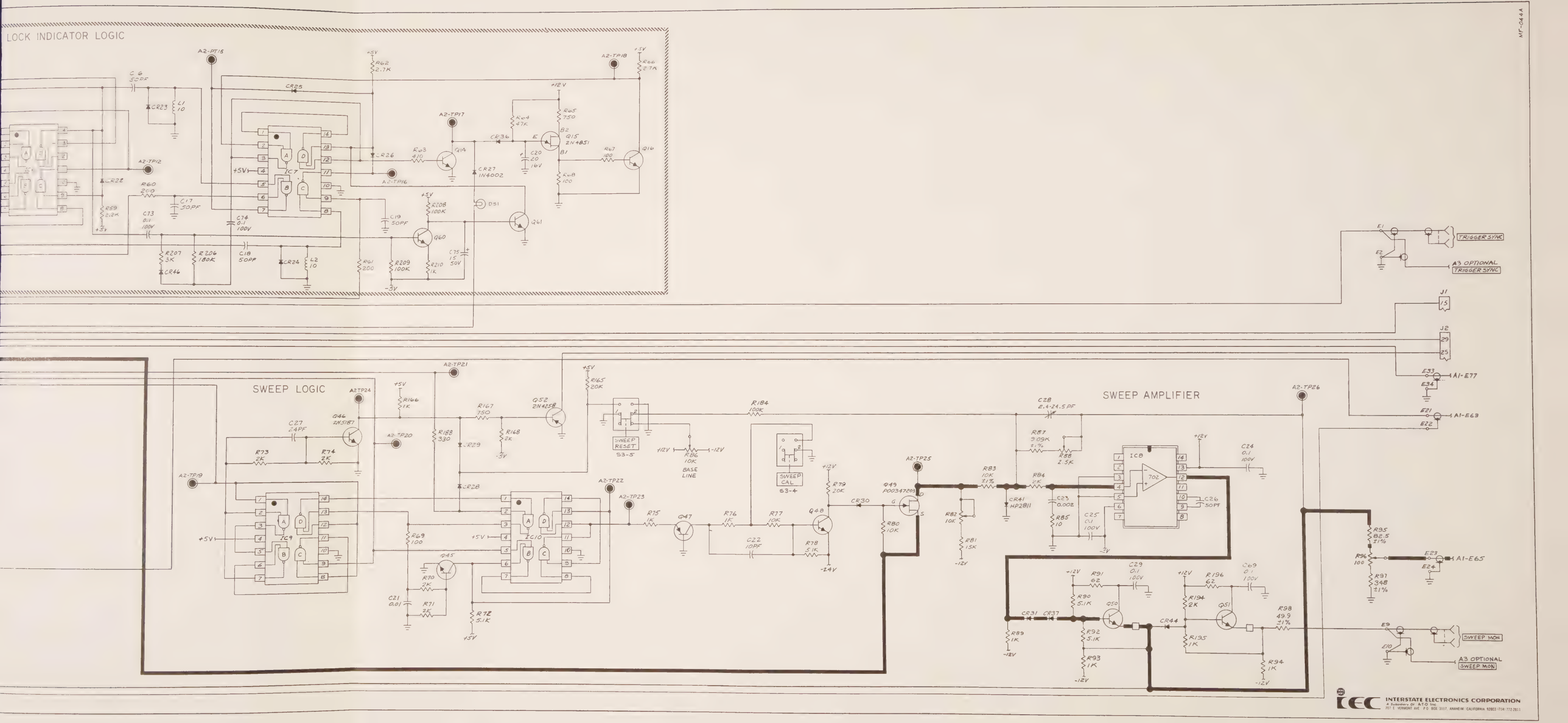
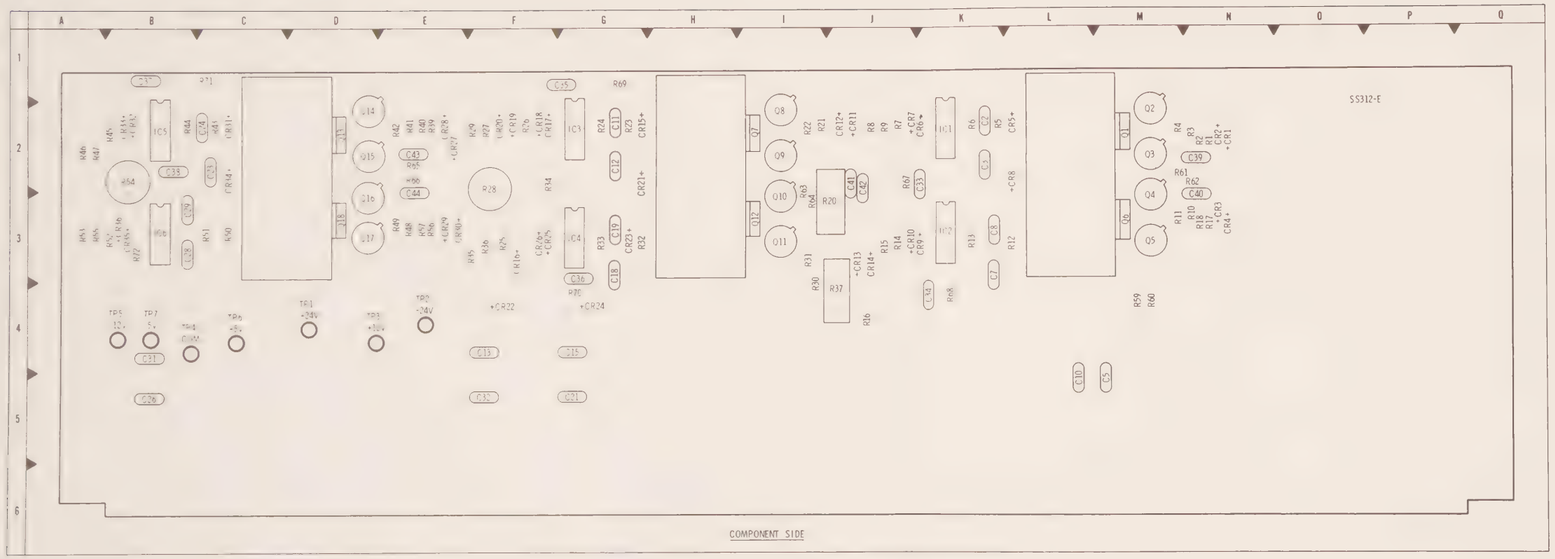
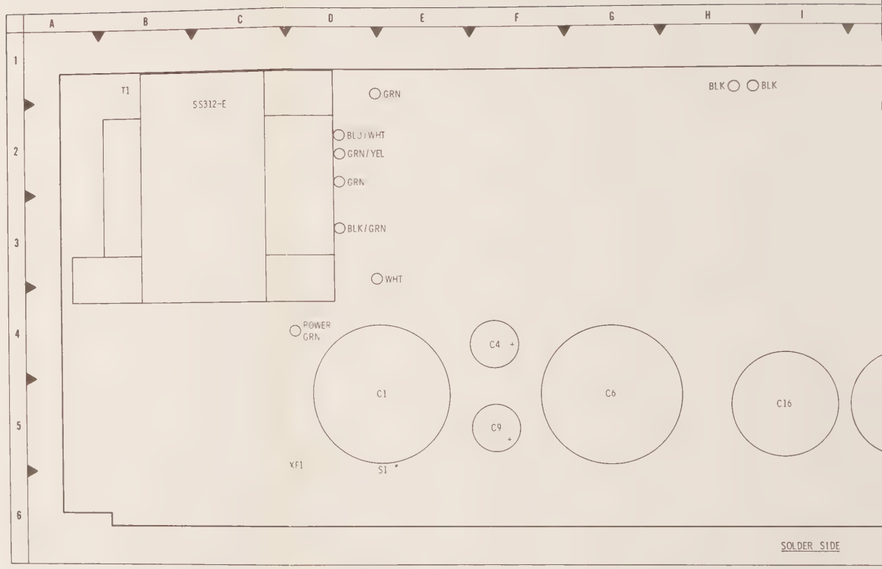


Figure 7-5. Auxiliary Board (A2) Schematic (Sheet 2 of 2 sheets)


A B C D E F G H I J K L M N O P Q
1 2 3 4 5 6
SS312-E
COMPONENT SIDE


A B C D E F G H I
1 2 3 4 5 6
T1
SS312-E
GRN
BLK
BLU/WHT
GRN/YEL
GRN
BLK/GRN
WHT
POWER GRN
C1
C4
C9
C6
C16
XF1
S1
SOLDER SIDE

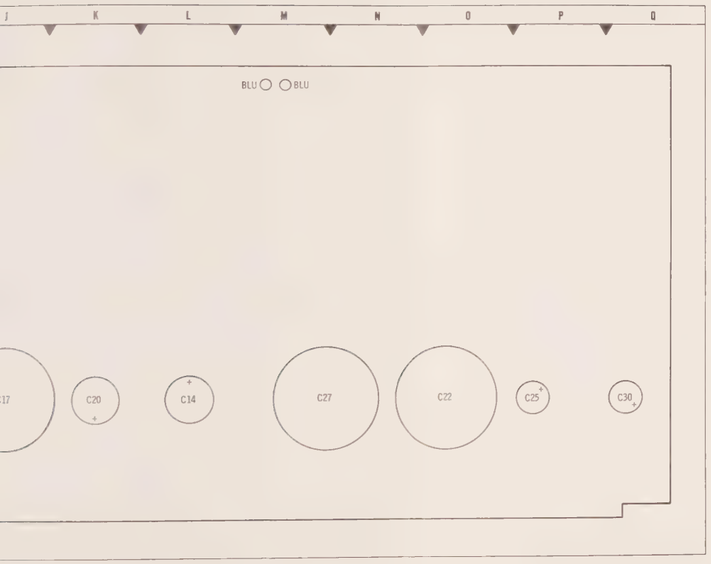


TABLE 7-3. POWER SUPPLY BOARD (A3) COMPONENT LOCATIONS

MF-0548A

REF DESIG	ZONE	REF DESIG	ZONE	REF DESIG	ZONE	REF DESIG	ZONE
FRONT							
C2	K2	CR14	J3	R1	N4	R49	E3
C3	K3	CR15	G2	R4	M2	R50	C3
C5	M4	CR16	F1	R5	N2	R51	C2
C7	N1	CR17	F2	R6	M2	R52	B3
C8	N3	CR18	F2	R7	N2	R54	B2
C10	L4	CR19	F2	R8	J2	R56	E3
C11	M2	CR20	F2	R9	J2	R57	E3
C12	G2	CR21	G2	R10	J2	R58	M4
C13	F4	CR23	G3	R11	N3	R60	M4
C14	G4	CR24	G4	R12	M3	R61	N2
C15	G4	CR25	F3	R13	M3	R62	N2
C18	G3	CR26	F3	R14	L3	R63	I2
C19	G3	CR27	E3	R15	J3	R64	I3
C21	G5	CR28	E2	R16	J4	R65	E2
C22	C4	CR29	E3	R17	N3	R66	E2
C24	C2	CR30	E3	R18	N3	R67	J2
C26	B5	CR31	C2	R19	J3	R68	K4
C28	B3	CR32	B2	R20	J3	R69	G3
C29	B3	CR33	B2	R21	I2	R70	G4
C30	B4	CR34	C2	R22	I2	R71	C3
C31	F5	CR35	B3	R23	G2	R72	B3
C33	K4	CR36	B3	R24	G2	TP1	D4
C34	K4	IC1	N2	R25	F3	TP2	E4
C35	G1	IC2	N3	R26	F2	TP3	E4
C36	G2	IC3	G2	R27	F2	TP4	B4
C37	B1	IC4	G3	R28	F2	TP5	B4
C38	B2	IC5	B2	R29	F2	TP6	C4
C39	N2	IC6	B3	R30	J3	TP7	B4
C40	N2	Q1	M4	R31	I3	REAR	
C41	J2	Q2	M4	R32	G3	C1	E5
C42	J2	Q3	M2	R33	G3	C4	F4
C43	E2	Q4	M2	R34	F2	C6	G5
C44	E3	Q5	M3	R35	F3	C9	F5
C91	N2	Q6	M3	R36	F3	C14	L5
CR1	N2	Q7	I4	R37	J3	C16	I5
CR2	N3	Q8	I2	R38	E2	C17	J5
CR4	N3	Q9	I2	R39	E2	C20	K5
CR5	L2	Q10	I3	R40	E2	C22	C5
CR6	N2	Q11	I3	R41	E2	C25	P5
CR7	J2	Q12	I3	R42	E2	C27	N3
CR8	L2	Q13	D2	R43	C2	C30	Q5
CR9	N3	Q14	D2	R44	B2	S1	E5
CR10	J3	Q15	D2	R45	B3	F1	C5
CR11	J2	Q16	D3	R46	A2	T1	C2
CR12	J2	Q17	D3	R47	A2		
CR13	J3	Q18	D3	R48	E3		

Figure 7-6. Power Supply Board (A3) Component Locations

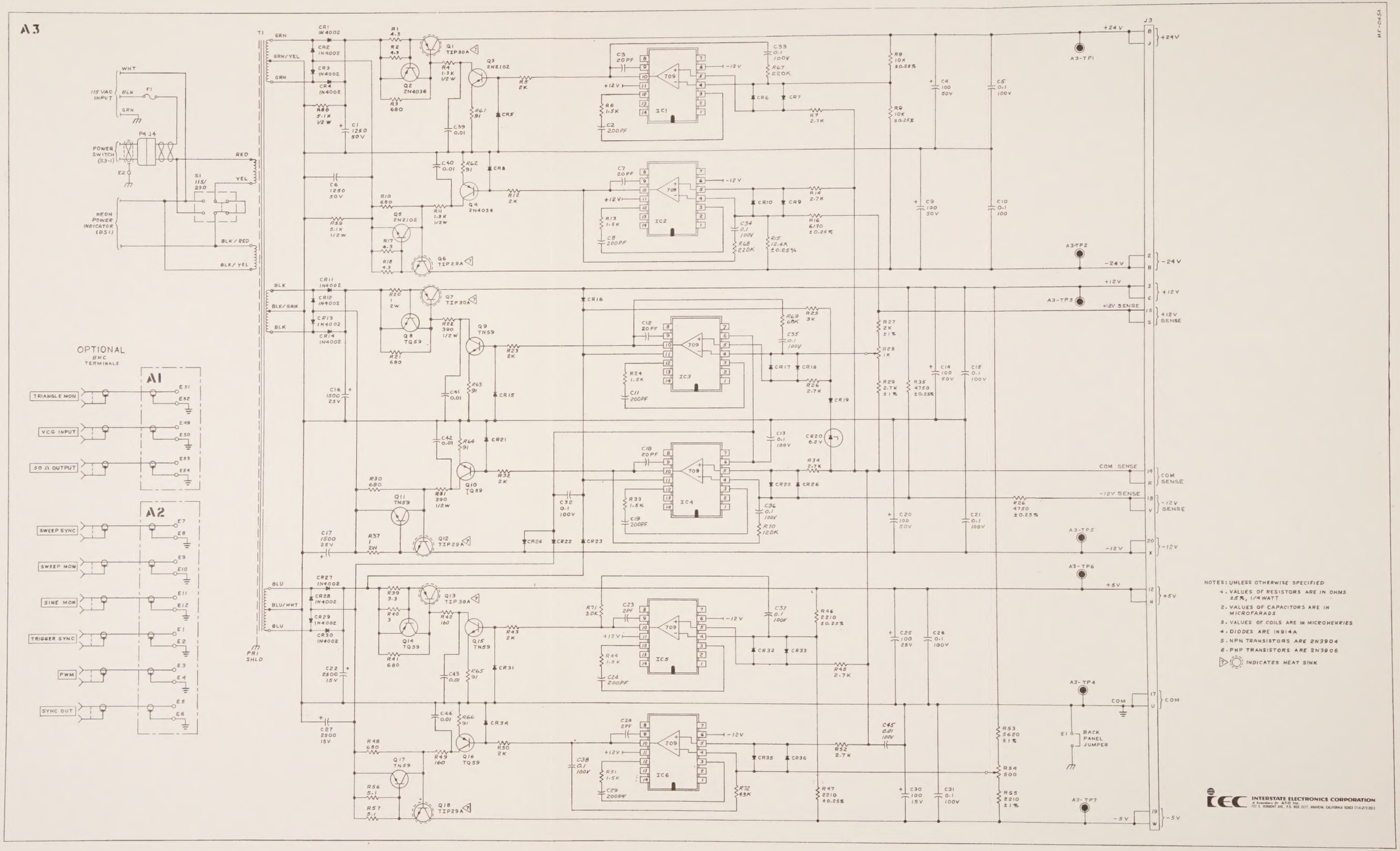


Figure 7-7. Power Supply Board (A3) Schematic

MP MASTER
MA28299

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